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Circular No. 637

Wheat Storage in Experimental Farm-Type Bins

By

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UNITED STATES DEPARTMENT OF AGRICULTURE

WASHINGTON, D. C., APRIL 1942

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Statement of Cooperation

This bulletin is a joint contribution of the Bureaus of Agricultural Chemistry and Engineering, and Plant Industry, and the Agricultural Marketing Service of the United States Department of Agriculture, the State Agricultural Experiment Stations of North Dakota, Kansas, Maryland, and Illinois, and the State Mill and Elevator of North Dakota.

In North Dakota H. F. McColly, of the Department of Agricultural Engineering, T. H. Hopper, formerly of the Division of Agricultural Chemistry, R. H. Harris, Chairman of the Cereal Technology Department, and other members of the North Dakota Agricultural Experiment Station staff assisted in the planning and conduct of the work. C. F. Kelly, associate agricultural engineer represented the Bureau of Agricultural Chemistry and Engineering from 1936 to 1938 and M. G. Cropsey, junior agricultural engineer of that Bureau assisted in the work from 1938 to 1941 inclusive.

F. C. Fenton of the Agricultural Engineering section, and C. O. Swanson of the Milling Industry Section of the Kansas Agricultural Experiment Station, L. C. Aicher, Superintendent of the Fort Hays Branch and other staff members gave valuable assistance in planning and conducting the Kansas experiments. The Bureau of Agricultural Chemistry and Engineering, United States Department of Agriculture representatives were A. D. Edgar, associate agricultural engineer, in 1936, and W. R. Swanson, junior agricultural engineer from 1937 to 1941.

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M. G. Cropsey and W. R. Swanson of the Bureau of Agricultural Chemistry and Engineering, assisted in preparing portions of the manuscript.

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INTRODUCTION

The storage of wheat on the farm would often give growers a marketing advantage. Government loans in recent years have also given farmers increased incentive to store wheat on the farm. Maintaining the quality of wheat in farm storages for several years presents many problems relative to storage structure and initial condition of wheat. To find an answer to some of these problems, a research program, supported by Bankhead–Jones funds, was instituted in 1936 by the United States Department of Agriculture, represented by the Bureau of Agricultural Chemistry and Engineering, the Bureau of Plant Industry, and the Bureau of Agricultural Economics,[1] and the Agri-

[1] At the beginning of this program part of the work was assigned to the Bureau of Agricultural Economics. Effective July 1, 1939 that part of the work was transferred to the newly created Agricultural Marketing Service.

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cultural Experiment Stations of North Dakota, Kansas, Illinois, Maryland, Ohio, Michigan, and Minnesota. In 1936 and 1937 the State Mill and Elevator of North Dakota also cooperated by lending large quantities of wheat for use in the experiments in that State. The Bureau of Agricultural Chemistry and Engineering constructed experimental bins, arranged for storage of the wheat, made wheat temperature and weather observations, and assisted in the taking of samples; the Agricultural Marketing Service graded the wheat according to the United States official grain standards and made fat acidity, milling, and baking tests; and the Bureau of Plant Industry made germination tests and studies of mold growth. The State Agricultural Experiment Stations furnished technical assistance, instruments, sites for the experimental bins, and in some cases loaned wheat for filling the bins.

The general objectives of this investigation were to determine what types of storage structures will best preserve the quality of wheat stored on farms and to find the maximum wheat moisture contents safe for long-time storage in bins of various designs. The purpose of this circular is to present the findings of the studies relating to moisture contents of wheat that are safe for storage in various types of storage structures on the farm in the various wheat-growing areas, and to bring up to date the information given in previous publications based on this investigation (*3*, *4*).[2]

PROCEDURE

In order to learn the influence of differences in climate, harvesting practices, and classes of wheat upon the requirements for storage, experiments were carried on at the four widely separated locations shown in figure 1. College Park, Md., and Urbana, Ill., represent the soft red winter wheat area, with harvest coming in late June and early July. Hays, Kans., is in the hard red winter wheat area with harvest in June or July. Fargo, N. Dak., is in the hard red spring wheat area with harvest in August. In Maryland, wheat for farm storage is usually cut with a binder and left in the shock or stack until dry enough to be threshed. In Illinois and North Dakota both shock threshing and combining are common, while in Kansas combining is the prevailing practice.

The field studies were made with experimental bins of from 20 to 1,000 bushels capacity. These were filled with wheat of the desired moisture content, then closely observed for as long as necessary to determine the usefulness of the equipment and methods or the suitability of the kind of wheat for long-time storage. Several surveys of wheat stored on farms were also made in 1936, 1937, and 1939. The different storage structures were compared by noting the temperature changes of the grain in different parts of the bin, the rates at which moisture was removed from the stored wheat, the official grade of the wheat when placed in storage and during the storage period, and the changes in the condition of the wheat as indicated by its fat acidity,[3] percent germination, and milling and baking tests.

Temperatures of the stored wheat were obtained with thermo-

[2] Italic numbers in parentheses refer to Literature Cited, p. 141.

[3] The fat-acidity determination is a chemical test based upon the amount of free fatty acids in the wheat. Fat acidity is measured by the number of miligrams of potassium hydroxide required to neutralize the free fatty acids in 100 grams of wheat.

couples placed in representative locations and read by means of a potentiometer. Average samples were taken from the bins with standard grain probes and analyzed by skilled technicians to determine moisture content, grade, germination,[4] and fat acidity. In order to learn the condition of the wheat in different parts of the bins, additional samples were taken from selected locations and analyzed in a similar manner. The amount of grain in the experimental bins was

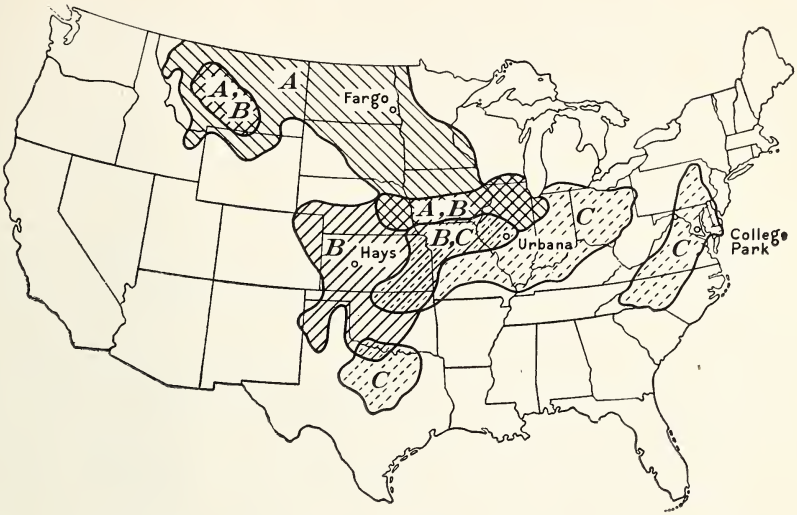

FIGURE 1.—Principal wheat-producing areas and the locations at which experimental work was conducted: *A*, Hard red spring wheat area; *B*, hard red winter wheat area; *C*, soft red winter wheat area.

estimated on a volume basis, assuming that 1¼ cubic feet equals 1 bushel (60 pounds) of wheat.

DETERIORATION OF WHEAT IN STORAGE

Deterioration of wheat in storage is usually caused by the activity of microorganism and by excessive respiration of the wheat kernel Heat is evolved both by microorganisms and by insects and by excessive respiration of the wheat kernel. Heat and moisture are evolved by these agencies at a rate depending to a large extent on the moisture content of the wheat. If the heat and moisture so generated are not removed promptly, the rates of respiration and deterioration may increase rapidly. Unless the heat and excess moisture are removed, this self-accelerating process will continue until the grain is unfit for human consumption.

In wheat stored in bins of the same size and type, and under similar outside temperature conditions, wheat moisture content usually becomes the factor influencing to the greatest degree the rate of deterioration of the grain. Changes in quality of wheat stored in the same

[4] The term "germination" as used throughout this circular refers to the viability of the wheat as determined by tests.

season in similar bins, but at moisture contents of 15.3 and 13.4 percent are shown in figure 2. Both lots of wheat were stored at Hays in 1937. As shown, the increase in fat acidity and in percent of total damage and decrease in percent of germination were rapid at the moisture content of 15.3 percent but very slow at 13.4 percent

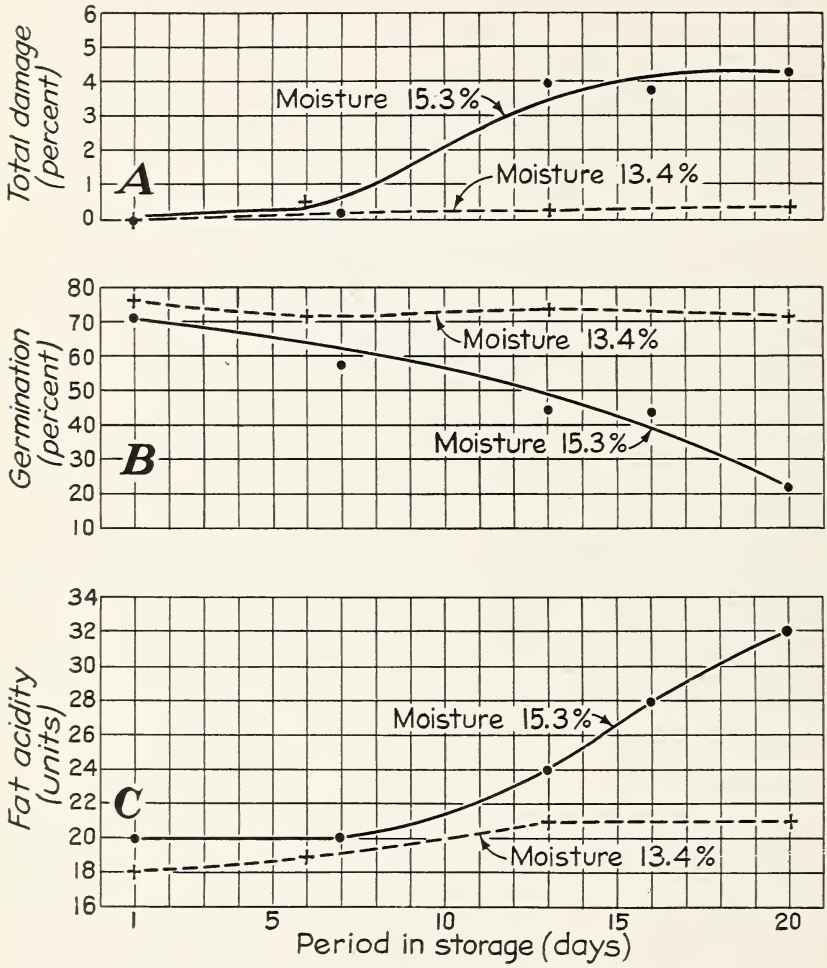

FIGURE 2.—Changes in quality of wheat stored at moisture contents of 15.3 and 13.4 percent in two similar bins at Hays in 1937: *A*, Change in percentage of total damage; *B*, change in percentage of germination; *C*, change in fat acidity.

moisture content. However, in the discussion on page 37 it is pointed out that for storage periods of more than a few months even a wheat moisture content of 13.4 percent may be too high for safe storage in this locality.

Measures of Wheat Quality

In the investigations reported herein, consideration was given to changes in factors which reflect the quality of the wheat during the storage period. These included the grade factors—moisture content, test weight per bushel, damage, foreign material, and odor, and other measures of quality such as germination percentage, fat acidity (*9*, *11*), and milling and baking tests. Tests of germination and fat acidity are given for the majority of the samples on which grade determinations were made, and these factors are also used for indicating the quality of the wheat for many samples on which grade determinations were not made, such as in the section on page 108 relating to the rate of deterioration as affected by wheat moisture content and temperature.

It is of interest to know the relationship each of these various measurements of wheat quality bears to others. Because on all grade samples taken since 1937 both germination and fat acidity tests were made in addition to the grade factor determinations, it was possible to determine the relationship between fat acidities and the percentage of normal germination and total damage. Few samples obtained had a fat acidity below 10 units, and at a fat acidity of 40 units the grain ordinarily had developed an abnormal odor; hence the study is limited to this range. A somewhat similar study has been made on corn by Zeleny and Coleman (*10*). The percentages of germination and total damage for each unit of fat acidity between 10 and 40 units are given in table 1 for the wheat stored at Fargo, N. Dak.; Hays, Kans.; College Park, Md.; and Urbana, Ill. The number of samples averaged in each group and the standard deviation for both percent germination and percent total damage are also given. The relationships between fat acidity and the factors of percent germination and percent total damage are shown graphically in figures 3, 4, 5, and 6, for North Dakota, Kansas, Maryland, and Illinois, respectively. All germination percentages are reported for normal germination only, and do not include abnormal germination. Samples from both ventilated and unventilated bins are included. The curves are drawn freehand. Further analyses of the data may reveal that the type of storage affects the relations among the various measurements of deterioration.

The curves indicate good agreement between the different indices of deterioration. The external evidences of wheat deterioration (such as percentage of total damage, test weight, odor, etc.) usually are not apparent until the condition of the grain has been lowered enough to affect its official grade. However, percentage of germination and fat acidity of sound wheat were found in these investigations to be valuable indices of incipient deterioration that is not apparent from grade examination.

In general, for any given value of fat acidity the percentage of germination was considerably lower in the wheat stored at Hays and College Park than at Fargo and Urbana. Similarly, at the lower values of fat acidity, from 10 to 30 units, the percentage of total damage was lower at each fat-acidity value in the wheat stored at Urbana and Fargo than at the other two stations. However, at 40 units these differences between locations were not so apparent.

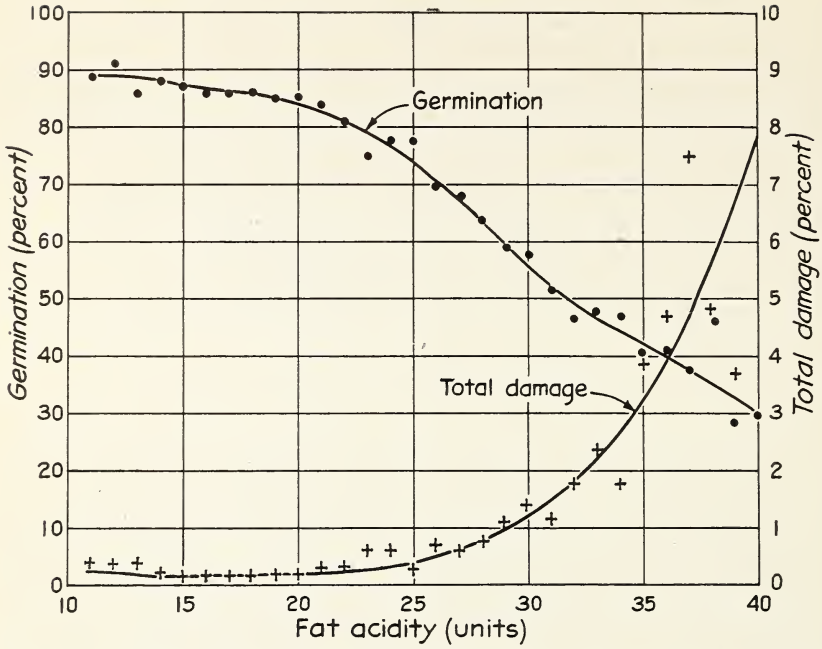

FIGURE 3.—Relation of fat acidity to percentages of germination and total damage. Based on 1,139 samples of hard red spring wheat from 30 experimental ventilated and unventilated bins at Fargo.

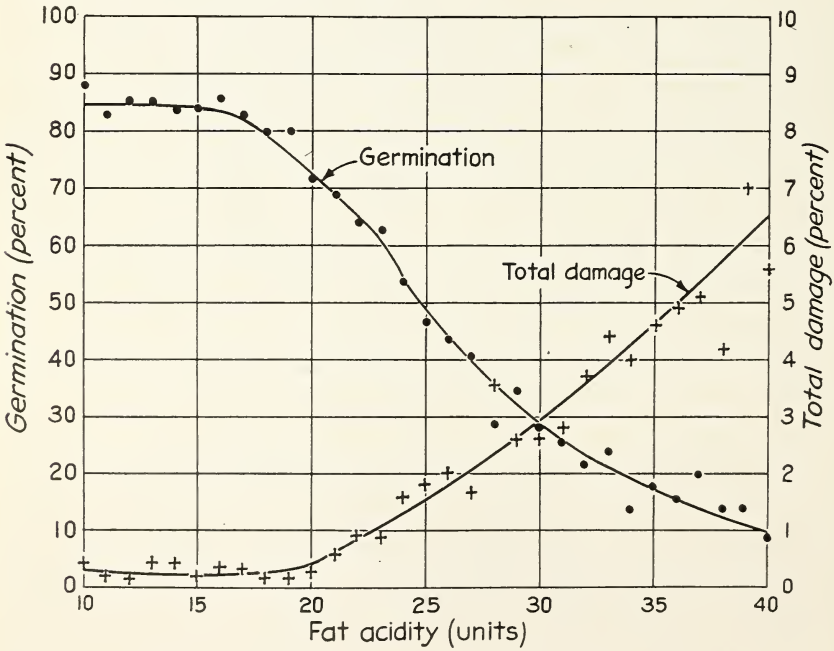

FIGURE 4.—Relation of fat acidity to percentages of germination and total damage. Based on 653 samples of hard red winter wheat from 39 experimental ventilated and unventilated bins at Hays.

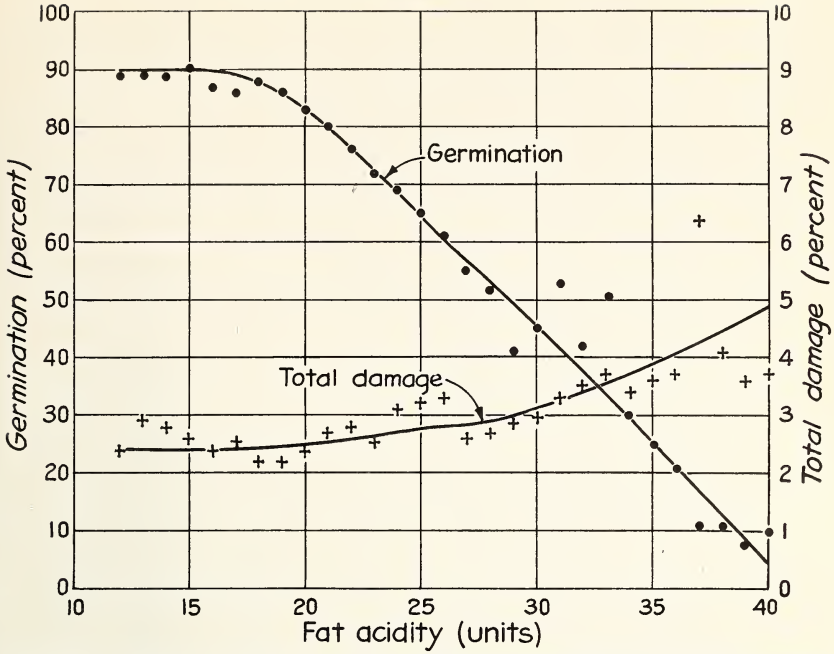

FIGURE 5.—Relation of fat acidity to percentages of germination and total damage. Based on 729 samples of soft red winter wheat from 18 experimental ventilated and unventilated bins at College Park.

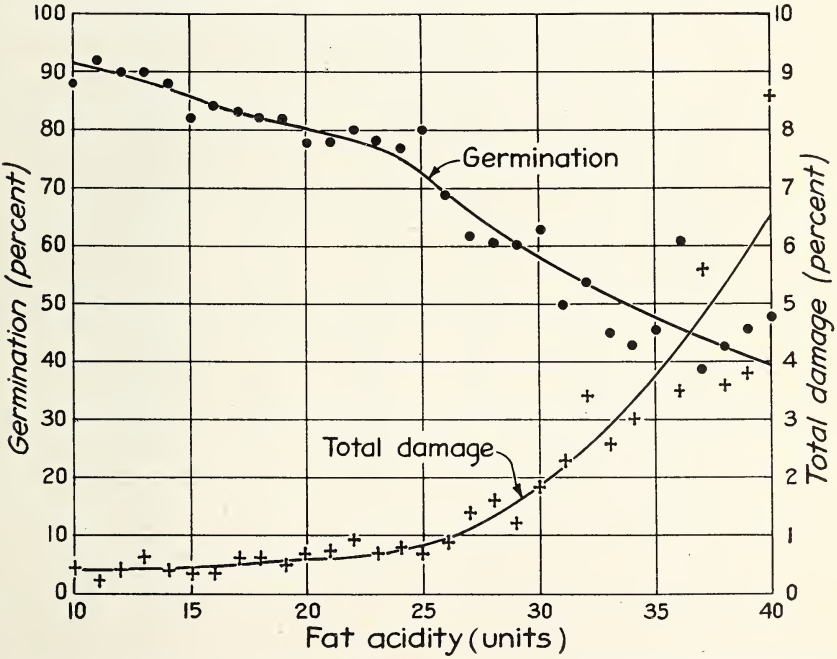

FIGURE 6.—Relation of fat acidity to percentages of germination and total damage. Based on 572 samples of soft red winter wheat from 17 experimental ventilated and unventilated bins at Urbana.

TABLE 1.—*Fat acidity, normal germination, and damaged kernel content of wheat stored in experimental bins at Fargo, Hays, College Park, and Urbana*

HARD RED SPRING WHEAT, FARGO

Fat acidity	Samples in group	Normal germination		Total damage	
		Average	Standard deviation	Average	Standard deviation
Units	*Number*	*Percent*	±*Percent*	*Percent*	±*Percent*
11	5	89	2.24	0.4	0.10
12	2	91	2.83	.4	.10
13	3	86	1.00	.4	.29
14	2	88	2.83	.2	.29
15	19	87	2.77	.2	.12
16	58	86	3.73	.2	.16
17	109	86	2.96	.2	.14
18	139	86	3.28	.2	.20
19	131	85	3.16	.2	.17
20	67	85	4.12	.2	.16
21	58	84	3.80	.3	.19
22	36	81	5.38	.3	.30
23	20	75	7.37	.6	.40
24	35	78	7.40	.6	.90
25	29	78	5.80	.3	.28
26	55	70	8.70	.7	.69
27	44	68	8.82	.6	.47
28	56	64	8.60	.8	.84
29	43	59	9.67	1.1	1.18
30	36	58	9.12	1.4	1.78
31	32	52	10.39	1.2	.94
32	25	47	12.96	1.8	1.96
33	20	48	13.56	2.4	2.33
34	19	47	12.45	1.8	1.47
35	25	41	15.72	3.9	3.47
36	17	41	15.20	4.7	2.91
37	16	38	14.28	7.5	8.06
38	11	47	12.14	4.8	4.10
39	14	29	15.17	3.7	4.85
40	13	30	18.66	15.9	9.49

HARD RED WINTER WHEAT, HAYS

10	2	88	2.83	0.4	0.1
11	4	83	2.00	.22	.45
12	7	85	2.92	.11	.17
13	9	85	3.33	.4	.18
14	8	84	2.54	.4	.36
15	17	84	4.01	.2	.30
16	28	86	5.14	.3	.77
17	27	83	7.69	.3	.66
18	60	80	8.99	.2	.40
19	42	80	9.79	.2	.31
20	66	72	10.00	.3	.49
21	61	69	11.32	.6	.83
22	51	64	12.88	.9	1.40
23	60	63	10.86	.9	1.47
24	31	54	14.73	1.6	2.10
25	20	47	13.73	1.8	2.63
26	11	44	15.75	2.0	1.60
27	13	41	10.87	1.7	1.29
28	23	29	13.96	3.6	4.58
29	18	35	13.56	2.6	1.68
30	18	28	10.77	2.7	2.37
31	15	26	11.62	2.8	2.44
32	9	22	8.66	3.7	2.35
33	16	24	10.90	4.4	3.98
34	5	14	10.00	4.0	2.40
35	8	18	8.50	4.6	2.71
36	3	16	12.77	4.9	1.76
37	6	20	6.29	5.1	2.23
38	4	14	6.05	4.2	1.41
39	5	14	6.16	7.0	6.31
40	6	9	3.03	5.6	.97

TABLE 1.—*Fat acidity, normal germination, and damaged kernel content of wheat stored in experimental bins at Fargo, Hays, College Park, and Urbana*—Con.

SOFT RED WINTER WHEAT, COLLEGE PARK

Fat acidity	Samples in group	Normal germination		Total damage	
		Average	Standard deviation	Average	Standard deviation
Units	*Number*	*Percent*	±*Percent*	*Percent*	±*Percent*
10	2	86	1	4.1	0.10
11	--------	--------	----------	--------	----------
12	5	89	2.55	2.4	.81
13	8	89	3.38	2.9	.95
14	11	89	3.60	2.8	.72
15	21	90	2.67	2.6	.78
16	23	87	4.68	2.4	.86
17	46	86	3.51	2.5	.94
18	41	88	3.43	2.2	.86
19	76	86	5.23	2.2	1.04
20	78	83	5.42	2.4	1.07
21	60	80	5.54	2.7	1.18
22	58	76	8.91	2.8	1.40
23	57	72	10.12	2.6	.93
24	37	69	10.36	3.1	1.67
25	29	65	12.98	3.2	1.73
26	22	61	14.28	3.3	1.70
27	12	55	11.69	2.6	.61
28	23	52	16.25	2.7	.49
29	14	41	19.09	2.9	.58
30	23	45	20.74	3.0	.78
31	9	53	19.33	3.3	.37
32	14	42	17.08	3.5	1.53
33	7	51	14.79	3.7	.52
34	9	30	14.16	3.4	.30
35	12	25	22.53	3.6	.10
36	8	21	12.68	3.7	.46
37	10	11	4.07	6.4	5.35
38	3	11	7.81	4.1	.70
39	6	8	5.35	3.6	.51
40	5	10	5.02	3.7	.54

SOFT RED WINTER WHEAT, URBANA

10	2	88	7.81	0.4	0
11	5	92	4.85	.24	.158
12	11	90	4.95	.35	.425
13	9	90	6.19	.63	.533
14	9	88	6.99	.35	.141
15	27	82	3.88	.39	.122
16	45	84	4.88	.4	.112
17	49	83	4.70	.56	.10
18	60	82	4.43	.57	.168
19	37	82	4.39	.53	.161
20	16	78	9.67	.61	.197
21	28	78	11.34	.7	.153
22	38	80	10.70	.9	.799
23	27	78	10.02	.7	.220
24	31	77	9.71	.75	.228
25	20	80	8.66	.7	.152
26	26	69	8.07	.93	.725
27	23	62	16.48	1.4	1.50
28	24	61	13.25	1.6	1.38
29	12	60	19.05	1.2	1.13
30	12	63	11.27	1.8	1.34
31	12	50	16.64	2.3	1.68
32	12	54	5.66	3.4	1.67
33	12	45	7.77	2.6	1.40
34	4	43	3.0	3.0	1.14
35	3	46	2.55	1.4	.91
36	5	61	10.88	3.5	2.55
37	4	39	16.37	5.6	7.31
38	3	43	7.94	3.6	1.54
39	3	46	9.54	3.8	2.63
40	3	48	4.74	8.6	.12

WHEAT STORAGE IN NORTH DAKOTA

A moisture content of 14.5 percent is the maximum allowed for hard red spring wheat under the numerical grades of the Official Grain Standards of the United States unless the word "Tough" is added to the grade designation, except that if the wheat moisture content is above 16 percent the grain is of Sample grade. While these moisture limits are in accord with commercial usage they do not necessarily represent the maximum moisture content safe for storage on the farm. In determining the maximum moisture content for safe storage in any given area, consideration must be given to the length of time the wheat is to be stored, the size and type of bin, and the initial condition of the wheat in regard to test weight, percent damage, etc. The following discussion is intended to point out, as found in these investigations, (1) the maximum moisture content for safe storage for various lengths of time in typical farm bins; (2) the effect of bin size on safe storage, and (3) the effect of bin type on safe storage.

Effect of Wheat Moisture Content on Storage in Unventilated Bins

The moisture content of the wheat used in the 1936 tests, which was down to 11 percent as a result of drought, was raised to more than 15 percent by the addition of water. As a result, it heated in the car while en route to Fargo and was slightly sour when placed in the bins. Further heating occurred in the unventilated bins before the experiment was closed in November of that year. These bins are briefly described and the changes in wheat quality given in tables 34 and 35 in the appendix.

Because all of the wheat in farm bins sampled in the surveys of 1936 was of such low moisture content and the wheat was left in storage for such short periods, as discussed on page 95 under Surveys of Bins on Farms, the data are of little value in establishing the maximum moisture limits for long-time safe storage.

In 1937 it was decided to use wheat of several moisture contents, to determine the maximum moisture content for safe keeping in unventilated storages. In the tests the wheat was stored in several 1,000-bushel metal bins divided in the center on the north-south axis into two 500-bushel bins. Bins F–1 and F–2 were the east and west halves, respectively, of one granary, and F–3 and F–4 the east and west halves of another. They were all identical except in floor construction. F–1 had the standard metal floor laid on 2– by 10-inch planks set tight together, F–2 had a concrete floor, and F–3 and F–4 wood floors consisting of 1- by 4-inch fir flooring laid over 2- by 10-inch planks. Partly as a check on bin F–1 and partly to determine the effect of material of construction on the length of safe storage, two wood bins, F–10 and F–12, were filled with wheat from the same lot as was placed in F–1, all being of 14.5 percent moisture content. Bin F–10 was the east half of a single-wall wood structure 12 by 14 feet in plan, and bin F–12 was the east half of another identical structure except for a lining of 1- by 6-inch tongue-and-groove boards on the inside of the studs. All bins, except F–2 with the concrete floor, were built about 2 feet above the ground level on piers of concrete blocks (fig. 7). The concrete floor was at the same level, but, of course, rested on a fill.

The wheat used for filling the bins was shipped in by rail and was well mixed. No water was added to the wheat to raise its moisture content, as in 1936. Data regarding the grain at the time of filling, and at various times during the storage period, are given in table 2, in which the bins are grouped according to the initial moisture content of the wheat; that is, 14.2-percent-moisture wheat in bins F–3 and F–2, 14.5-percent-moisture wheat in F–1, F–10, and F–12, and 15 percent in bin F–4.

All bins were sampled at 1-week intervals during the summer and at 1-month intervals during the winter, until March 21, 1938, when, after 200 days' storage, two of the bins (F–3 and F–4) were emptied and the wheat in a third (F–12) was moved. At this time (March 21) as shown by table 2, wheat of all moisture contents was in very good condition, although the test weight and percent germination had decreased slightly more in the wheat of 14.5 percent or greater moisture content.

The three other bins, F–1, F–2, and F–10, filled with the wheat of 14.2 and 14.5 percent original moisture content, remained under observation for some time longer. The first indication of the development of spoilage was noted in the wooden bin F–10 (14.5 percent moisture) on September 30, 1938, after 410 days of storage, when the average sample was musty. Although the musty odor persisted, it is interesting to note that samples taken on February 7, 1939, after 540 days of storage showed that only 4 or 5 bushels of wheat in the top of the bin near the south side had actually deteriorated to a great degree, while the rest of the wheat was in good condition, showing little loss in test weight and germination or increase in percent damage or fat acidity. If this small amount of out-of-condition wheat had been removed from the bin, the rest of the grain would have had a natural odor.

FIGURE 7.—View of bins at Fargo, showing concrete block piers.

TABLE 2.—*Variation in condition of wheat during storage period when stored at Fargo, at 14.2, 14.5, and 15.0 percent initial moisture content*

Sample type	Quantity of wheat	Time of storage	Date sampled	Wheat moisture	Test weight per bushel	Dockage	Damage	Grade [1]	Odor	Germination	Fat acidity
	Bushels	*Days*		*Percent*	*Pounds*	*Percent*	*Percent*			*Percent*	*Units*
BIN F-3 (METAL, WITH WOOD FLOOR) STORED AT 14.2 PERCENT MOISTURE CONTENT [2]											
Average	462	1	Sept. 11, 1937	14.2	55.0	2.5	0.4	3	Natural	86	17
Do [3]	462	190	Mar. 21, 1938	14.2	54.8	2.8	.2	4	do	84	19
BIN F-2 (METAL, WITH CONCRETE FLOOR) STORED AT 14.2 PERCENT MOISTURE CONTENT											
Average	500	0	Sept. 14, 1937	14.2	55.3	1.3	0.3	3	Natural	89	16
Do	500	187	Mar. 21, 1938	14.3	55.5	1.8	.1	3	do	86	17
Do	500	379	Sept. 29, 1938	13.8	55.6	1.4	.3	3	do	86	24
Do	500	533	Mar. 2, 1939	14.5	55.1	1.4	.0	3	do	77	25
Do	500	660	July 6, 1939	13.8	55.0	1.6	2.0	3	do	66	28
Inferior [4]	5	664	July 10, 1939	14.6	54.8	1.8	1.0	Sample, Tough	Musty	44	30
Remainder [5]	495	664	do	13.6	56.0	.4	.5	3	Natural	68	26
Average	500	955	Aug. 13, 1940	13.6	55.0	1.5	1.8	3	do		31
Do [6]	500	1,237	Jan. 6, 1941	13.8	55.0	.8	4.0	Sample	Musty	36	34
BIN F-1 (METAL WITH METAL FLOOR OVER PLANKS) STORED AT 14.5 PERCENT MOISTURE CONTENT											
Average	500	1	Aug. 17, 1937	14.5	55.6	1.5	Trace	3	Natural	90	19
Do	500	217	Mar. 21, 1938	14.6	55.3	1.2	0.1	3 Tough	do	82	23
Do	500	410	Sept. 30, 1938	14.2	54.8	.8	.9	4	do	66	28
Do	500	536	Feb. 3, 1939	14.4	54.7	1.2	.8	4	Fumigant	48	29
Inferior [4]	5	540	Feb. 7, 1939	16.2	51.4	.8	16.0	Sample	Musty	8	44
Remainder [5]	495	540	do	14.3	54.5	.9	2.3	4	Natural	53	26
Average [6]	500	562	Mar. 2, 1939	14.8	53.8	1.0	.9	Sample, Tough	Musty	35	34
BIN F-10 (SINGLE-WALL WOOD BIN) STORED AT 14.5 PERCENT MOISTURE CONTENT											
Average	500	1	Aug. 17, 1937	14.5	55.8	0.8	.0	3	Natural	88	18
Do	500	217	Mar. 21, 1938	14.3	55.5	.6	.1	3	do	82	18
Do	500	386	Sept. 6, 1938	14.1	55.7	.6	.3	3	do	80	25
Do [6]	500	410	Sept. 30, 1938	14.4	54.7	1.1	2.4	Sample	Musty	70	28
Do	500	536	Feb. 3, 1939	14.6	54.4	.9	2.3	do	do	61	28
Inferior [4]	5	540	Feb. 7, 1939	16.3	51.7	1.1	12.3	do	do	33	37
Remainder [5]	495	540	do	14.0	55.4	.6	.2	3	Natural	74	25

BIN F-12 (DOUBLE-WALL WOOD BIN) STORED AT 14.5 PERCENT MOISTURE CONTENT

Average	500	1	Aug. 17, 1937	14.5	55.8	0.8	0	3	Natural	89	19
Do [7]	500	217	Mar. 21, 1938	14.4	55.5	.9	.1	3	do	82	18

BIN F-4 (METAL, WITH WOOD FLOOR) STORED AT 15.0 PERCENT MOISTURE CONTENT

Average	500	3	Sept. 11, 1937	15.0	53.5	5.0	0.2	4 Tough	Natural	86	18
Do [3]	500	194	Mar. 21, 1938	15.0	53.2	4.5	.4	do	do	80	19

[1] All wheat of class Hard Red Spring and subclass Dark Northern Spring.
[2] Wheat in bin F-3 mixed and elevated several times before Sept. 11. Wheat in bin F-2 artificially dried from 15.8 percent moisture content to 14.2 percent.
[3] Wheat sold.
[4] Inferior portion of 4 to 5 bushels of wheat located at top of bin near south side.
[5] Remainder of wheat, excluding inferior portion.
[6] First average sample from bin having musty odor.
[7] Last sample before moving wheat.

The wheat in the metal bin (F–1), also originally at 14.5 percent moisture content, did not develop an abnormal odor throughout the bin or show other indication of advanced deterioration until February 7, 1939 (540 days of storage), when an inferior portion of 4 or 5 bushels was found in the top layers of wheat near the south side of the bin. It was not until 22 days later (March 2, 1939) that the average sample from the entire bin had a musty odor. At the time the small portion of inferior wheat was found, the rest of the grain still had a normal odor, but had dropped one numerical grade (No. 3 Dark Northern Spring to No. 4 Dark Northern Spring) because of loss in test weight.

The wheat in bin F–2, originally with a moisture content of 14.2 percent, was in storage in good condition 664 days when an inferior and out-of-condition portion amounting to about 5 bushels was found in the upper layers in the sampling of July 10, 1939. On January 6, 1941, after 1,237 days of storage, the entire bin was out of condition. No average samples for the bin as a whole were taken between August 13, 1940, when the wheat was in good condition, and January 6, 1941; hence the exact time of going out of condition is not known.

In the foregoing discussion, the development of an abnormal odor was used as an indication that the wheat was in poor condition. As was shown, usually some time elapses between the date the first inferior portion, possibly quite small, appears and the date the entire bin develops a musty odor. For ordinary purposes, where the grain is to be marketed through regular commercial channels, this second condition probably represents the end of the period of safe storage and the appearance of small inferior portions should be considered as a warning that conditions dangerous for continued safe storage are developing. By removing small spoiled portions when first found, the storage period undoubtedly could be increased over that observed in this investigation where the wheat was not disturbed until the entire mass had developed a sour or musty odor. Table 3 was prepared to summarize the information just presented and to give for the various wheat moisture contents the period of safe storage by the two standards; that is, (1) when the first abnormal odor is found in a small portion of the wheat and (2) when the entire lot of wheat develops a musty odor. Because a third criterion may sometimes be used where the wheat is being saved for seed, the normal germination percentage is given in each case where available.

TABLE 3.—*Safe storage period until first abnormal odor develops and until abnormal odor develops in entire bin, as shown by tests at Fargo, with wheat of the 1937 crop*

Item	Original wheat moisture (percent)		
	14.2	14.5	15.0
Storage period [1] before development of abnormal odor:			
In entire lot of wheat ..... days	1,096	473	[2] 217
In small inferior portion ..... do	664	(3)	.....
Normal germination when abnormal odor was first observed:			
In entire lot of wheat ..... percent	36	52	.....
In small portion of wheat ..... do	[4] 68	(3)	.....

[1] Found by averaging, for the bins concerned, the days in storage until the first abnormal odor was observed and the days until the nearest preceding sample.
[2] As wheat was removed before going out of condition, this information represents at least the minimum for this particular moisture content.
[3] Samples from inferior portion not drawn until after average sample indicated musty odor. See text.
[4] For balance of bin, excluding inferior portion.

In the tests just described, and in investigations in other years, it was observed that the wheat ordinarily went out of condition first in only one location, usually in the upper part of the bin, and that this portion of the wheat was of higher moisture content than the remainder. To determine whether this was due to a movement of moisture between levels in the bin or an accumulation of moisture in any part,

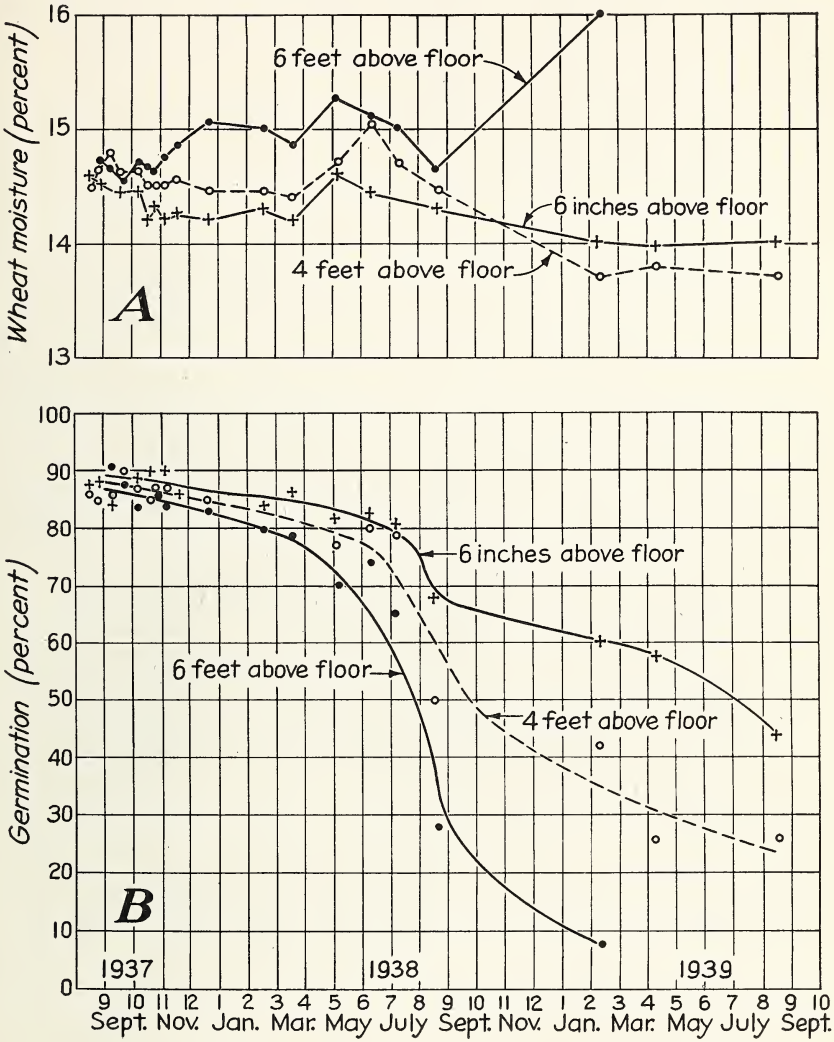

FIGURE 8.—Variation in wheat moisture content (*A*) and germination percentage (*B*) at levels 6 inches, 4 feet, and 6 feet above the floor in bin F–1, filled at Fargo in 1937.

and if this had any relation to the rate of deterioration, a schedule of sampling planned to obtain horizontal probe samples from points 6 inches, 4 feet, and 6 feet above the bin floor was started. Moisture,

grade factor data, germination percentage, and fat-acidity determinations were made on these samples. These data for the same dates at which grade factors and other information are included in table 2 for the 1937 unventilated bins are arranged in table 4 for convenience in comparing. The changes in moisture content and percent germination of the wheat at the three levels are shown graphically in greater detail in figure 8 for bin F–1 filled with wheat of 14.5 percent moisture, and in figure 9 for bin F–2, filled with wheat of 14.2 percent moisture.

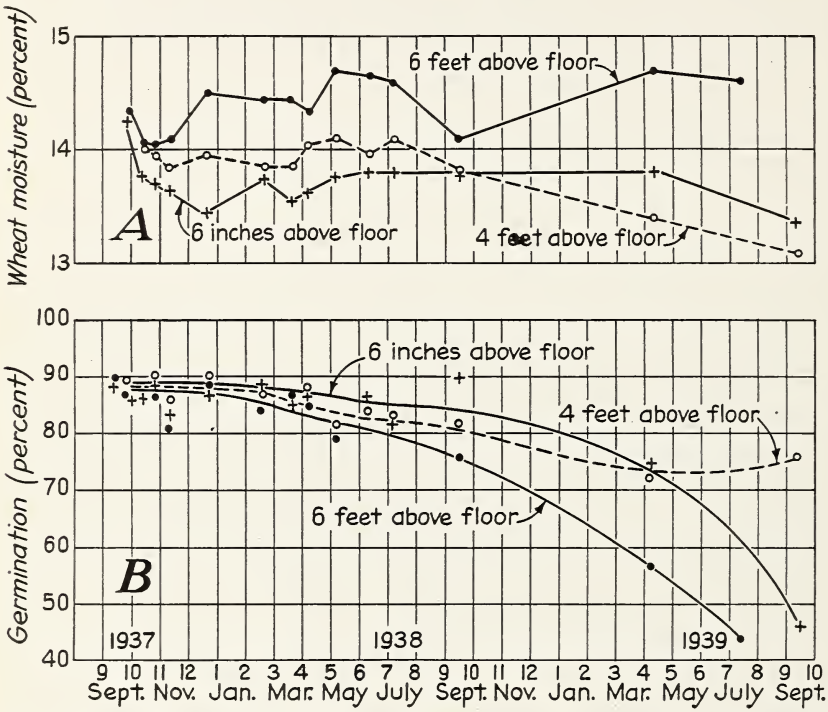

FIGURE 9.—Variation in wheat moisture content (*A*) and germination percentage (*B*) at levels 6 inches, 4 feet, and 6 feet above the floor in bin F–2, filled at Fargo in 1937.

TABLE 4.—*Wheat moisture content, percentage germination, and fat acidity at 6 inches, 4 feet, and 6 feet from the bin bottom at various times. Bins filled in 1937 at Fargo with wheat of 14.2, 14.5, and 15.0 percent initial moisture content*

Bin F–3 (metal, with wood floor), stored at 14.2 percent moisture content

Date sampled	Average for bin			Distance of sample from bottom of bin								
				6 feet			4 feet			6 inches		
	Moisture content	Germination	Fat acidity	Moisture content	Germination	Fat acidity	Moisture content	Germination	Fat acidity	Moisture content	Germination	Fat acidity
	Percent	*Percent*	*Units*	*Percent*	*Percent*	*Units*	*Percent*	*Percent*	*Units*	*Percent*	*Percent*	*Units*
Sept. 11, 1937	14.2	86	17	14.4	86	19	14.0	85	18	14.0	86	18
Mar. 21, 1938	14.2	84	19	15.3	80	18	14.0	82	18	13.6	88	17

See footnotes at end of table.

TABLE 4.—*Wheat moisture content, percentage germination, and fat acidity at 6 inches, 4 feet, and 6 feet from the bin bottom at various times. Bins filled in 1937 at Fargo with wheat of 14.2, 14.5, and 15.0 percent initial moisture content*—Con.

Date sampled	Average for bin			Distance of sample from bottom of bin								
				6 feet			4 feet			6 inches		
	Moisture content	Germination	Fat acidity	Moisture content	Germination	Fat acidity	Moisture content	Germination	Fat acidity	Moisture content	Germination	Fat acidity
	Percent	*Percent*	*Units*	*Percent*	*Percent*	*Units*	*Percent*	*Percent*	*Units*	*Percent*	*Percent*	*Units*
Bin F-2 (metal, with concrete floor), stored at 14.2 percent moisture content												
Sept. 14, 1937	14.2	89	16	14.2	90	16	13.9	88	16	14.2	89	16
Mar. 21, 1938	14.3	86	17	14.4	87	17	13.8	84	16	13.6	85	16
Sept. 29, 1938 [1]	13.8	86	24	14.1	76	22	13.8	82	24	13.8	90	20
Mar. 2, 1939 [2]	14.5	77	25	14.7	57	28	13.4	72	25	13.8	81	24
Bin F-1 (metal with metal floor over planks), stored at 14.5 percent moisture content												
Aug. 17, 1937	14.5	90	19	14.5	86	17	14.5	86	18	14.6	87	18
Mar. 21, 1938	14.6	82	23	14.8	79	22	14.4	86	20	14.2	86	19
Sept. 30, 1938 [3]	14.2	66	28	14.6	28	33	14.4	50	27	14.3	68	26
Feb. 3, 1939	14.4	48	29	14.9	10	42	13.7	42	29	14.0	60	29
Mar. 2, 1939 [2]	14.8	35	34	15.6	8	51	13.8	26	35	14.0	58	29
Bin F-10 (single wall wood bin), stored at 14.5 percent moisture content												
Aug. 17, 1937	14.5	88	19	14.6	88	19	14.5	90	19	14.6	84	19
Mar. 21, 1938	14.3	82	18	15.0	84	19	14.3	86	19	14.4	87	17
Sept. 6, 1938 [3]	14.1	80	25	14.8	35	32	14.2	68	24	14.2	------	22
Feb. 3, 1939	14.6	61	28	15.0	19	34	13.5	72	25	13.6	88	20
Bin F-12 (double wall wood bin), stored at 14.5 percent moisture content												
Aug. 17, 1937	14.5	89	19	14.5	84	19	14.5	86	19	14.5	90	18
Mar. 21, 1938	14.4	82	18	15.2	83	18	14.4	------	20	14.4	82	18
Bin F-4 (metal, with wood floor), stored at 15 percent moisture content												
Sept. 11, 1937	15.0	86	18	15.2	88	18	15.0	87	18	14.9	86	19
Mar. 21, 1938	15.0	80	19	15.6	71	21	14.6	80	19	14.6	82	18

[1] Samples from 6-inch, 4-foot, and 6-foot levels drawn Sept. 14, 1938.
[2] Samples from 6-inch, 4-foot, and 6-foot levels drawn Apr. 4, 1939.
[3] Samples from 6-inch, 4-foot, and 6-foot levels drawn Aug. 17, 1938.

The last point in each curve representing the 6-foot level, for both moisture content and germination, is for the inferior sample given for that date in table 2.

It is apparent that at 6 feet above the floor the moisture content of the wheat soon increased above that of the average of the bin, and that this was accompanied by greater deterioration as indicated by decrease in germination and increase in fat acidity. At the same time the wheat in the upper part of the bin showed an increase in moisture, that in the lower part of the bin (6-inch and 4-foot levels) showed a decrease below the bin average with correspondingly lower rates of deterioration. The changes, especially as regards moisture, were rather small, but are sufficiently consistent, taken in connection with the differences in rates of deterioration, to justify these conclusions.

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It is doubtful whether all of the moisture increase in the upper levels is due to movement from the bottom. Other observations indicate that a large part of it may have resulted from absorption of moisture from the air, or from snow blowing in through cracks. In North Dakota it is extremely difficult to make the bins tight against blowing snow. (Fig. 10.)

It is not always possible to place in storage wheat of uniform moisture content, especially if the combine is used for harvesting, and this presents another problem. In 1938 metal bins F–3 and F–4 were refilled with wheat combined near Fargo, passed through a fanning mill for cleaning, and placed directly in the bins. Because of the great variation in the moisture content of individual truckloads, both bins received wheat of higher and lower moisture content than the average; in bin F–3 the average was 14.9, the maximum 15.8, and

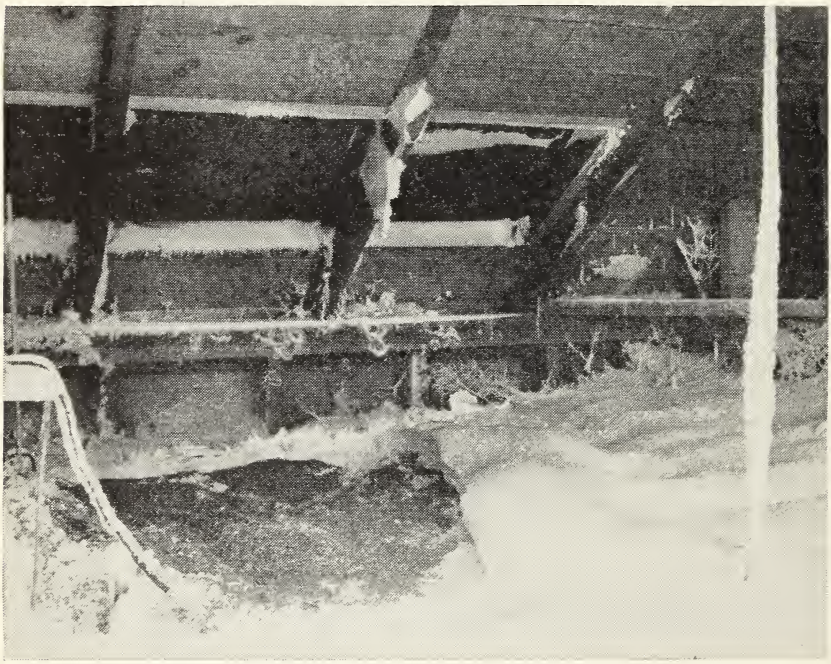

FIGURE 10.—Snow which blew into the top of bin F–12 during the blizzard of March 15, 1941. This bin was well constructed and tighter at the eaves and between the rafters than most farm bins. Part of the snow has been removed to show depth.

the minimum 13.8 percent; in bin F–4 the average was 13.7, the maximum 15.8, and the minimum 11.2 percent. The wheat in bin F–3 (14.9 percent), placed in storage on August 3, 1938, increased in temperature very rapidly at the points having the highest moisture contents, i. e., near the top of the bin between the center and south side, and on August 23 it was necessary to move and turn the wheat for mixing and cooling. The condition of the wheat at this time, as shown in table 5, was inferior, approximately one-fifth of it having a musty odor. After mixing by means of a portable elevator, it was returned to the same bin for further observation but, although the moisture was

TABLE 5.—*Variation of condition of wheat of 1938 crop, initially very uneven in moisture content, while in storage at Fargo*

Sample type	Quantity of wheat	Time in storage	Date sampled	Wheat moisture content	Test weight per bushel	Dockage	Damage	Grade [1]	Odor	Germination	Fat acidity
	Bushels	*Days*		*Percent*	*Pounds*	*Percent*	*Percent*			*Percent*	*Units*
BIN F-3 (METAL WITH WOOD FLOOR)											
Average	450	0	Aug. 3, 1938	[2] 14.9	56.0	0.9	0	3, Tough	Smutty	81	25
Do.[3]	450	20	Aug. 23, 1938	14.9	55.6	1.1	.4	3, Tough, Smutty	do	59	28
Inferior [4]	90	20	do	15.8	54.6	.5	8.5	Sample, Tough, Smutty	Musty	18	45
Remainder [5]	360	20	do	14.8	57.2	.5	.4	2, Tough	Natural	89	22
BIN F-3, AFTER MOVING TO COOL WHEAT											
Average	450	0	Aug. 26, 1938	14.4	56.1	1.2	1.8	3, Light smutty	Fumigant	62	29
Do	450	161	Feb. 3, 1939	14.3	56.0	.8	2.8	do	do	50	34
Do	450	188	Mar. 2, 1939	14.8	55.6	.7	1.7	Sample, Tough, Light smutty.	Musty	48	35
BIN F-4 (METAL WITH WOOD FLOOR)											
Average	440	1	Aug. 4, 1938	[6] 13.7	58.8	0.9	0	1	Natural	86	20
Do.[3]	440	38	Sept. 10, 1938	14.3	57.3	.8	.6	2	do	50	30
At 4-foot level [7]		38	do	14.6	57.2	.8	1.0	Sample, Tough, Light smutty.	Musty	24	32
BIN F-4, AFTER MOVING TO COOL WHEAT											
Average	440	3	Sept. 16, 1938	14.2	57.8	1.1	0.6	2	Natural	66	26
Do	440	171	Mar. 2, 1939	14.2	57.5	.9	.2	2	do	54	31
Do	440	359	Sept. 7, 1939	13.6	58.0	.9	.3	1	do	56	34
Do	440	448	Dec. 5, 1939	13.6	58.0	1.0	1.5	1	do	49	36
Inferior [8]	5	450	Dec. 7, 1939	14.4	56.4	1.8	14.9	Sample	Musty	18	39
Remainder [9]	435	449	Dec. 6, 1939	13.4	58.2	.8	1.3	1	Natural	52	36
Average	440	699	Aug. 13, 1940	13.6	57.5	.8	2.0	2	do		41
Do	440	845	Jan. 6, 1941	13.5	57.8	1.0	6.3	3 [10]	do	37	42

[1] All wheat of class Hard Red Spring and subclass Dark Northern Spring.
[2] Wheat moisture content varied from 13.8 to 15.8 percent in bin.
[3] Before moving.
[4] Inferior portion consisting of ⅕ of wheat near top of bin.
[5] Remainder excludes all inferior wheat
[6] Wheat moisture content varied from 11.2 to 15.8 percent in bin.
[7] Horizontal probe across bin 4 feet above floor.
[8] Inferior sample represents 5 bushels 1 foot under top surface near south side of bin.
[9] Remainder sample represents remainder of wheat, excluding inferior portions.
[10] Grade factor is percent total damage.

much more evenly distributed throughout the bin, varying between only 14.6 percent and 13.6 percent, the wheat was musty when sampled on March 2, 1939, after 188 days of storage subsequent to the moving.

It was necessary on September 10, 1938, after 38 days in storage, also to turn the wheat in bin F–4 because of heating near the center where the moisture content was about 14.6 percent After the cooling and mixing, the wheat remained in good condition until December 7, 1939, when a small inferior and musty portion was found near the top of the bin on the south side, after 450 days in storage. However, at the latest sampling (January 6, 1941) 845 days after it was moved for mixing and cooling, the average sample drawn from the bin did not have a musty odor, although the quality of the grain as indicated by analysis for damage, germination, and fat acidity, was low.

Apparently uneven moisture content of stored wheat may cause it to react in a different manner than when the moisture content is uniform, as in the 1937 tests. In unventilated bins moisture does not equalize throughout the wheat and deterioration proceeds at a more rapid rate in the damp areas than in the dry.

Effect of Bin Size on Wheat Storage

For each 500-bushel bin (F–1, F–2, and F–4) filled in 1937, two 20-bushel bins were filled from the same lots of wheat or from similar wheat, to observe the effect of bin size on the rate of change of quality of the grain while in storage. These small unventilated bins were of two types—plain metal and metal insulated with 3 inches of rock wool. The inside diameter of each type was 40 inches and the height 36 inches. A one-half-inch opening was left at the eaves between the wall and roof for air circulation across the top of the wheat. The condition of the wheat as indicated by its moisture content, odor, temperature, germination, and fat acidity is shown in table 6, where the quality of the wheat in the three bins filled with the same kind of wheat can be easily compared for any date. No data are included in the table for any bin after the date the average sample in the bin was found to be musty. The small bins F–30, F–32, and F–34 were plain metal and F–31, F–33, and F–35 were insulated with rock wool. The small bins, except for bin F–32, a small plain metal bin in the 14.5-percent-moisture group, stayed in storage for a longer period without developing an abnormal odor than did the large bins with which they were paired.

The rate of loss of germination was also decidedly less in the small bins than in the large, and slightly less in the small insulated bins than in the small plain metal bins. This same relation between the bin size and deterioration as indicated by fat acidity is apparent in the 14.5-percent-moisture wheat but not in the 14- and 15-percent-moisture. It is probable that the differences in the rates of deterioration of the wheat in the two different size bins would have been much greater if it had not been for the fact that the moisture content of most of the small bins increased because of moisture absorbed from the air and from snow blown in through the openings at the eaves. For this reason the small bins sometimes had several percent more moisture than the large bins.

TABLE 6.—*Comparison of wheat moisture content, odor, percent germination and fat acidity observed in 500-bushel and 20-bushel bins* [1] *filled at Fargo in 1937*

INITIAL WHEAT MOISTURE CONTENT APPROXIMATELY 14.0 PERCENT

Date	Wheat moisture content for bin No.—			Wheat temperature for bin No.— [2]			Wheat odor for bin No.—			Germination for bin No.—			Fat acidity for bin No.—		
	F-2 500 bu.	F-34 20 bu.	F-35 20 bu.	F-2 500 bu.	F-34 20 bu.	F-35 20 bu.	F-2 500 bu.	F-34 20 bu.	F-35 20 bu.	F-2 500 bu.	F-34 20 bu.	F-35 20 bu.	F-2 500 bu.	F-34 20 bu.	F-35 20 bu.
	Percent	*Percent*	*Percent*	*°F.*	*°F.*	*°F.*				*Percent*	*Percent*	*Percent*	*Units*	*Units*	*Units*
Sept. 3, 1937	14.2	13.8	13.8	75	67	67	Natural	Natural	Natural	89	87	84	16	19	21
Dec. 21, 1937	14.4	14.0	14.0				do	do	do	85	88	88	16	18	17
Sept. 1, 1938	13.6	13.3	13.4	73	66	65	do	do	do	84	78	88	23	27	24
Dec. 1, 1938	14.0	13.6	13.7	44	22	22	do	do	do	78	83	85	24	26	25
Mar. 7, 1939	14.2	14.0	14.8	14	22	16	do	do	do	75	78	82	25	27	26
Sept. 7, 1939	13.6	12.1	12.8	76	69	67	do	do	do	63	70		26	28	26
Dec. 5, 1939	13.9	12.5	13.3				do	do	do	52	70	80	27	29	25
Aug. 13, 1940	13.6	13.5	13.1				do	do	do				31	33	32
Jan. 6, 1941	13.8	13.6	13.9				Musty	do	do	36	68	76	34	32	34

INITIAL WHEAT MOISTURE CONTENT 14.5 PERCENT

Date	Wheat moisture content for bin No.—			Wheat temperature for bin No.—[2]			Wheat odor for bin No.—			Germination for bin No.—			Fat acidity for bin No.—		
	F-1 500 bu.	F-32 20 bu.	F-33 20 bu.	F-1 500 bu.	F 32 20 bu.	F-33 20 bu.	F-1 500 bu.	F-32 20 bu.	F-33 20 bu.	F-1 500 bu.	F-32 20 bu.	F-33 20 bu.	F-1 500 bu.	F-32 20 bu.	F-33 20 bu.
	Percent	*Percent*	*Percent*	*°F.*	*°F.*	*°F.*				*Percent*	*Percent*	*Percent*	*Units*	*Units*	*Units*
Aug. 17, 1937	14.5	14.5	14.5	76	74	71	Natural	Natural	Natural	90	88	87	19	20	18
Dec. 21, 1937	14.5	14.6	14.6				do	do	do	86	87	83	19	17	17
Aug. 17, 1938	13.7	13.6	14.2	69	82	83	do	do	do	60	72	80	31	26	25
Dec. 1, 1938	14.2	14.0	14.4	43	22	21	do	do	do	50	55	65	30	29	29
Mar. 2, 1939	14.8	16.5	18.7	16	22	18	Musty	Musty	do	35	58	64	34	27	30
Apr. 6, 1939			17.0	18	43	38			do			52			25
May 6, 1939			15.2						Musty			44			28

[1] Bins F-34, F-32, and F-30 of plain metal construction, and bins F-35, F-33, and F-31 of metal insulated with 3 inches of rock wool.
[2] Average for the month, at the center of the bin. From tables 5 and 6, pages 33-34, U. S. Department of Agriculture, Circular 587, "Temperatures of Wheat in Experimental Farm-Type Storages."

TABLE 6.—*Comparison of wheat moisture content, odor, percent germination, and fat acidity observed in 500-bushel and 20-bushel bins filled at Fargo in 1937*—Continued

INITIAL WHEAT MOISTURE CONTENT APPROXIMATELY 15.0 PERCENT

Date	Wheat moisture content for bin No.—			Wheat temperature for bin No.—[2]			Wheat odor for bin No.—			Germination for bin No.—			Fat acidity for bin No.—		
	[3] F-4 500 bu.	F-30 20 bu.	F-31 20 bu.	F-4 500 bu.	F-30 20 bu.	F-31 20 bu.	F-4 500 bu.	F-30 20 bu.	F-31 20 bu.	F-4 500 bu.	F-30 20 bu.	F-31 20 bu.	F-4 500 bu.	F-30 20 bu.	F-31 20 bu.
	Percent	*Percent*	*Percent*	*°F.*	*°F.*	*°F.*				*Percent*	*Percent*	*Percent*	*Units*	*Units*	*Units*
Sept. 11, 1937	15.0	14.8	15.2	75	64	64	Natural	Natural	Natural	86	84	84	18	17	18
Dec. 21, 1937	15.2	15.0	15.1				do	do	do	78	86	84	19	17	17
Mar. 21, 1938	15.0	14.8	15.2				do	do	do	80	86	83	19	18	19
Sept. 6, 1938		14.0	14.1		67	68		do	do		48	61		29	29
Dec. 3, 1938		14.3	14.6		21	22		do	do		55	60		30	28
Apr. 7, 1939		17.4	15.2		43	43		do	do		44	53		28	28
May 6, 1939		14.6	14.8		68	63		Musty	do		39	56		29	28
Aug. 5, 1939			14.0			75			do			33			32
Sept. 9, 1939			13.1			64			Musty			40			32

[2] Average for the month, at the center of the bin. From tables 5 and 6, pages 33–34, U. S. Department of Agriculture, Circular 587, "Temperatures of Wheat in Experimental Farm-Type Storages."

[3] Emptied Mar. 25, 1938.

Effect of Ventilation

A detailed discussion of the studies of ventilated bins at Fargo is given in another publication (*3*). Since that time more data have been collected from several of the bins, and the results are brought up to date here.

As two of the main functions of a ventilation system are to remove heat and moisture from the grain before harm has resulted, there is little need for comparing ventilated and unventilated bins on the basis of initial moisture content or temperature. In most cases the initial moisture content of the wheat stored in ventilated bins was so high that an unventilated check bin filled with the same wheat would have gone out of condition quickly and been a needless expense. Therefore, in this circular the reactions of the wheat stored in ventilated bins of various types are compared with the reactions observed in unventilated bins filled with wheat of a moisture content reasonably sure of remaining in good condition for a year or more.

Three series of experiments were conducted on ventilation; one in 1936, one in 1937, and a third in 1938. In 1936, as stated before, it was necessary to add water to the wheat to bring it up to the desired moisture content of 15.5 percent. Seven ventilated bins were filled with this type of wheat. Diagrams of several of the bins are shown in figure 11. There was little loss of moisture from any of the bins, on the basis of average samples. However, all types of ventilation except that used in F–10 which had vertical flues, (fig. 11) were effective in preventing any increase in wheat temperature (*3*).

In 1937 six 500-bushel bins with various types of ventilating systems were filled with well-mixed wheat of approximately 15.5 percent natural moisture content. A brief description of each bin follows:

Bin F–5 was the east half of a 1,000-bushel, round, perforated-wall, metal bin, divided from the west half, on the north-south axis, by a corrugated-metal partition. The floor was of perforated metal of the type furnished by the manufacturer, with slots 1 inch long, and slightly less than the thickness of a kernel of wheat wide, spaced 3 inches on centers one way and 3½ inches the other. Installed in the center of the mass of grain was a half-round air-pressure chamber with a vertical height of 1 foot and a radius of 3½ feet. A 10-inch galvanized pipe extended horizontally from the air-pressure chamber to the bin wall, to conduct air from a 16-inch propeller-type fan, with a 1/12-horsepower motor. Air forced into the pressure chamber by the fan passed through 3½ feet of wheat before leaving the bin at the walls, floor, or upper wheat surface.

Bin F–6 was the west half of the same bin, having similar perforated walls but a floor with an area of the perforations about 10 times greater than in F–5. A pressure chamber of the same type was installed, but instead of using a small fan for air pressure, a large cowl, kept headed into the wind by a vane, was placed above the bin for ventilating with wind pressure (fig. 12).

Bin F–9 was used for testing a method of wind-assisted ventilation in which the distance of air travel through the wheat was less than in bin F–6. It was the west half of a 1,000-bushel single-wall wooden structure. Seven layers of flues were installed, each covering more than 90 percent of the horizontal cross-sectional area of the bin. One layer of flues was at the floor level and the other layers were spaced

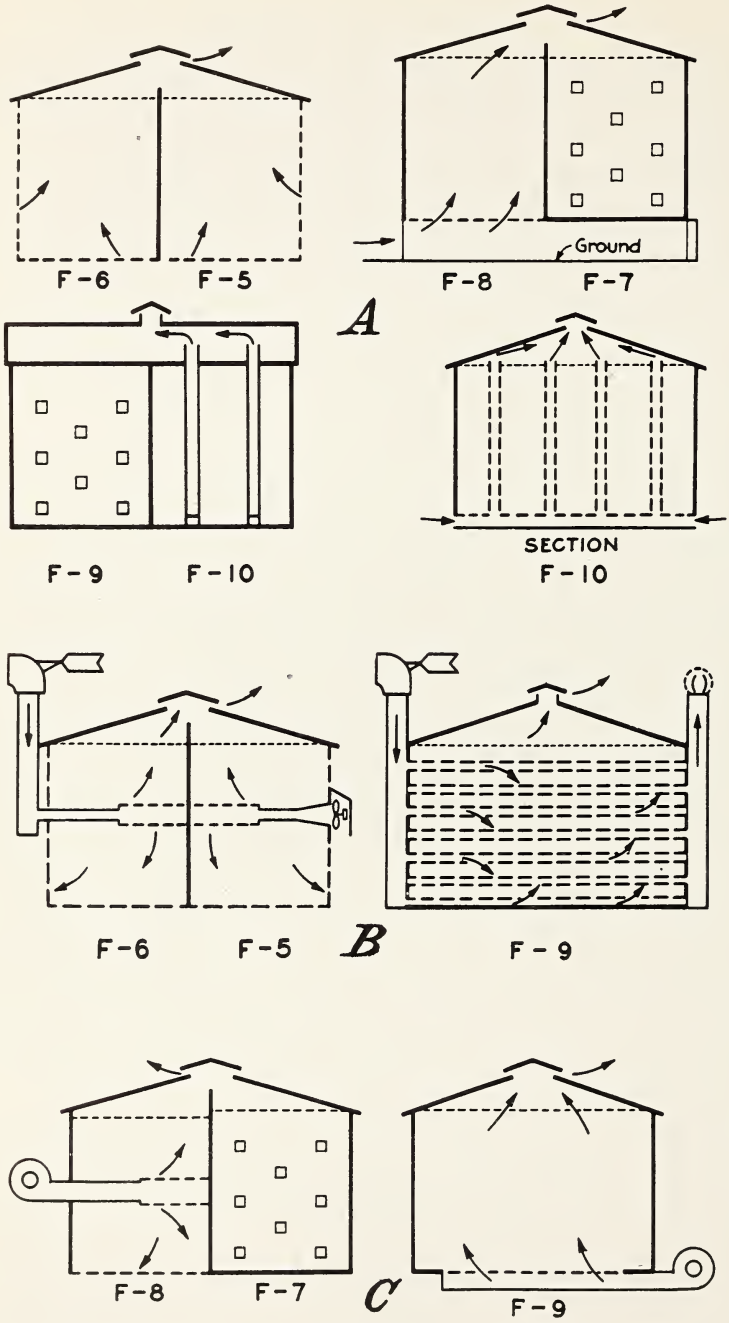

FIGURE 11.—Diagrams of ventilated bins used in tests at Fargo: *A*, 1936; *B*, 1937; *C*, 1938.

vertically at 14 inches between centers. This gave a distance in the clear, between flues, of approximately 11 inches. The first, third, fifth, and seventh layers from the floor were connected through a common manifold to a pressure cowl above the bin. The other three layers were connected to a turbine-type suction ventilator, also placed above the bin. The air path was from the pressure cowl to the inlet flues, through 11 inches of wheat to the outlet flues, and thence to the outside via the turbine-suction ventilator (fig. 11).

Bins F–7 and F–11 were equipped with horizontal flues of the type tested in North Dakota in 1928. Each flue was made of two 1- by

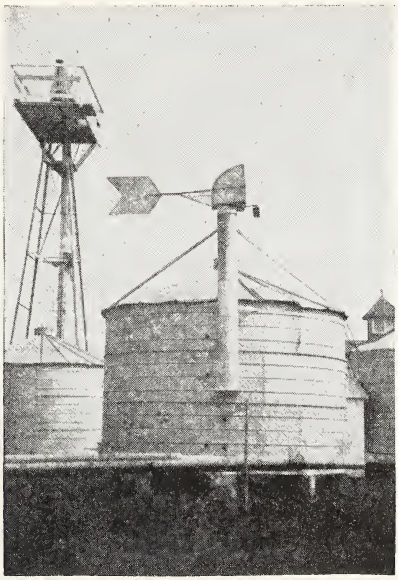

FIGURE 12.—Bin F–6 used at Fargo, in 1937, showing pressure cowl.

4-inch boards set on edge, about 5 inches apart, and covered top and bottom with fly screen. Bin F–7 was the east half of a round metal bin, with eight flues running north and south, arranged as shown in figure 11. A mixture of lime and flowers of sulfur was added to the wheat in this bin. It is discussed on page 124. Bin F–11, the west half of a 1,000-bushel double-wall wood bin, had eight ventilating flues of the North Dakota type installed with the same horizontal and vertical spacing as in F–7. The ends of all horizontal flues were provided with caps to exclude rain and snow but to allow a free flow of air.

Bin F–8, the west half of a 1,000-bushel, round, tight-wall metal bin, was equipped with a perforated metal floor and a large pressure chamber underneath the bin so that winds from the northwest (the direction of prevailing winds in that locality) would force air up through the wheat. Oats with a moisture content of 10.7 percent were mixed with the wheat in this bin at the time of filling. The action of the oats in removing moisture is also discussed in the section on Use of Fungicides, Insecticides, and Absorbents in Farm Wheat Storage; only the observations made after the oats were removed are considered here.

In the 1938 tests, bin F–7, the east half of a round, 1,000-bushel commercial, metal granary used in the 1937 tests, was used without alteration. The air drum and fan were removed from bin F–5, leaving it as a perforated-wall-and-floor metal bin with no other means of ventilation.

The air drum from bin F–5 was placed in the center of the 1937 bin F–8, at a distance of 4 feet above the floor (fig. 11). Air was supplied to the drum through an 8-inch metal pipe from the blower of a silo filler operated by a 3-horsepower electric motor. This bin had a perforated floor but solid walls, hence the path of air forced into the drum from the blower was through 3½ feet of wheat to the perforated floor or upper wheat surface.

The flues were removed from the 1937 bin F–9, and the flooring from between the two center joists was also removed, except for a distance of 18 inches in from the north and south walls. The bottom of the two joists from which the flooring had been removed was boxed in with tongue-and-groove boards, and the open space in the floor covered with perforated metal. The rectangular bin floor, approximately 7 by 12 feet, with a total area of 84 square feet, thus had in its center an air chamber with a surface 9 feet by 1 foot 2 inches, or a total area of 10½ square feet exposed to the wheat. Air was supplied to the air chamber through a 7-inch-diameter pipe by a farm-type pneumatic grain elevator driven by a 3-horsepower electric motor. The path of the air forced into the air chamber, when the bin was filled with wheat, was from the perforated metal surface in the floor, upward through 8 feet of wheat, and out through the upper wheat surface.

The 1937 experimental ventilated bins were filled on September 2, 1937, from two carloads of wheat averaging 15.5 percent in moisture content. The grade, germination, and fat acidity of the wheat in each bin, except F–7, at the time of filling and at intervals thereafter, until the wheat went out of condition or was disposed of, is shown in table 7.

Moisture was removed from all the bins at varying rates until about November 1, 1937 (*3*). After this date no drying was observed, the moisture content even increasing in several of the bins until, in the case of bins F–6 and F–11, drying again started in May 1938.

The wheat in bin F–11, having horizontal flues, dried at a slower rate in the fall of 1937 than did that in any of the other ventilated bins. On October 5 only 0.2 percent of the moisture had been removed as compared with 1.3 percent for bin F–9, 1.0 percent for F–5, and 0.8 percent for F–6.

The wheat in bin F–9, having the seven layers of horizontal flues connected to suction and pressure cowls, showed about the same decrease in moisture content in the fall of 1937 as did the wheat in bins F–5 and F–6. However, the average moisture content of the wheat began to rise in November. At the time the bin was emptied (March 21, 1938) the wheat near the bottom reached a moisture content of 16.8 percent, compared to 15.6 percent for the average of the bin. Part of this moisture increase may have been caused by water or snow entering through the manifolds and flues. Although the moisture content of the wheat was high in the bottom part of bin F–9, there was no evidence of caking or spoiling in any part when it was emptied.

TABLE 7.—*Variation of condition of wheat stored in ventilated bins at Fargo, filled in 1937 and 1938*

Sample type	Quantity of wheat	Time in storage	Date	Wheat moisture content	Test weight per bushel	Dockage	Damage	Grade [1]	Odor	Germination	Fat acidity
	Bushels	*Days*		*Percent*	*Pounds*	*Percent*	*Percent*			*Percent*	*Units*
BIN F-5—PERFORATED WALLS AND FLOOR, CENTRAL DRUM AND 16-INCH PROPELLER FAN, FILLED IN 1937											
Average	477	1	Sept. 2, 1937	15.4	53.3	4.7	(2)	4, Tough	Natural	87	18
Do	477	34	Oct. 5, 1937	14.4	53.2	4.1	0.2	4	do	85	19
Do	477	201	Mar. 21, 1938	14.1	53.6	4.2	.3	4	do	83	
BIN F-6—SAME CONSTRUCTION AS BIN F-5 EXCEPT USING COWL FOR AIR PRESSURE IN PLACE OF FAN, FILLED IN 1937											
Average	477	1	Sept. 2, 1937	15.8	53.1	3.6	0	4, Tough	Natural	88	18
Do	477	34	Oct. 5, 1937	15.0	54.0	3.1	(2)	do	do	85	19
Do	477	201	Mar. 21, 1938	14.4	53.3	3.6	.3	4	do	81	17
Do	477	547	Mar. 2, 1939	14.1	53.1	3.3	.5	4	do	74	24
Do	477	737	Sept. 8, 1939	13.0	53.6	3.7	.5	4	do	64	29
Bottom [3]	2	737	do	12.9	53.8	2.6	1.0	Sample	Musty	63	30
Average	477	911	Mar. 1, 1940	13.0	53.2	3.3	.9	4	Natural	68	23
Do	477	1,080	Aug. 17, 1940	13.2	53.0	3.4	1.0	4	do		36
Do	477	1,222	Jan. 6, 1941	13.2	53.0	3.8	5.0	Sample	Musty	58	36
Inferior [4]	40	1,222	do	17.8	48.2	3.2	60.0	do	do	3	57
Remainder [5]	437	1,222	do	12.9	53.5	3.7	4.0	do	do	51	37
BIN F-9—WOOD, NATURALLY VENTILATED WITH 7 LAYERS OF FLUES; WIND ASSISTED, FILLED IN 1937											
Average	400	1	Sept. 2, 1937	15.6	53.7	3.0	0.1	4, Tough	Natural	86	18
Do	400	34	Oct. 5, 1937	14.3	53.8	3.5	.3	4	do	84	18
Do	400	201	Mar. 21, 1938	15.6	52.2	3.1	(2)	5, Tough	do	79	16
BIN F-11—WOOD; HORIZONTAL FLUES, FILLED IN 1937											
Average	500	1	Sept. 2, 1937	15.6	53.2	3.4	(2)	4, Tough	Natural	90	18
Do	500	34	Oct. 5, 1937	15.4	53.2	4.2	0.2	do	do	83	20
Do	500	201	Mar. 21, 1938	15.0	53.7	3.8	.1	do	do	77	17
Do	500	548	Mar. 3, 1939	13.6	53.5	3.5	.6	4	do	66	26
Do	500	737	Sept. 8, 1939	13.3	53.7	3.8	.7	4	do	60	31
Do	500	914	Mar. 5, 1940	13.4	53.6	3.5	.5	4	do	58	(6)
Do	500	1,080	Aug. 13, 1940	13.4	53.2	3.2	.8	4	do		37
Do	500	1,222	Jan. 6, 1941	13.4	53.4	3.8	1.5	4	do	52	36

See footnotes at end of table.

TABLE 7.—*Variation of condition of wheat stored in ventilated bins at Fargo, filled in 1937 and 1938*—Continued

Sample type	Quantity of wheat	Time in storage	Date	Wheat moisture content	Test weight per bushel	Dockage	Damage	Grade	Odor	Germination	Fat acidity
	Bushels	*Days*		*Percent*	*Pounds*	*Percent*	*Percent*			*Percent*	*Units*
BIN F-8—METAL, PERFORATED FLOOR; AFTER REMOVAL OF OATS, FILLED IN 1937											
Average	350	8	Sept. 28, 1937	14.5	53.0	5.0	0.2	4	Natural	80	22
Do	350	182	Mar. 21, 1938	14.3	53.5	4.7	.6	4	do	85	
BIN F-5—PERFORATED METAL WALLS AND FLOOR (BEFORE MOVING), FILLED IN 1938											
Average	470	1	Aug. 3, 1938	14.9	56.2	0.9	0.2	3, Tough	Smutty	71	23
Do	470	27	Aug. 29, 1938	14.6	55.4	1.1	.6	Sample, Tough	Musty	64	31
Inferior [7]	95	27	do	16.1	53.0	1.8	4.8	Sample	do	22	48
Remainder [8]	375	27	do	14.0	56.5	1.2	.7	3	Natural	78	23
BIN F-5 (AFTER MOVING)											
Average [9]	470	1	Aug. 31, 1938	14.3	55.8	1.1	2.0	3	Fumigant	62	31
Do	470	184	Mar. 2, 1939	14.5	55.7	1.2	1.4	3	Natural	61	35
Do	470	373	Sept. 7, 1939	13.6	56.2	1.1	2.6	3	Fumigant	47	39
Do	470	448	Mar. 1, 1940	13.4	56.0	1.1	4.0	3	do	54	38
Do	470	613	Aug. 13, 1940	13.0	56.2	1.3	4.0	3	Natural		43
Do	470	759	Jan. 6, 1941	12.8	56.2	1.2	8.2	Sample	Musty	50	44
BIN F-7—METAL WITH 8 HORIZONTAL FLUES SPACED 2 FEET ON CENTERS, FILLED IN 1938											
Average	505	1	Aug. 3, 1938	15.4	56.6	1.1	(2)	3, Tough, Light Smutty	Natural	78	20
Do	505	29	Aug. 31, 1938	14.8	55.3	.8	11.0	Sample, Tough	Musty	51	37
Inferior [10]	101	29	do	19.9	49.8	5.6	54.4	Sample	do	4	58
Remainder [11]	404	29	do	13.6	56.0	1.3	.2	3, Weevily	Fumigant	88	18

BIN F-8—PERFORATED FLOOR; FORCE VENTILATED THROUGH CENTRAL DRUM, FILLED IN 1938

Average	495	1	Aug. 3, 1938	15.1	56.5	0.8	0	3, Tough	Smutty	76	20
Do	495	32	Sept. 3, 1938	13.4	56.8	.8	1.2	3	do	73	23
Do	495	213	Mar. 3, 1939	13.4	56.6	.6	.8	3	Natural	75	25
Do	495	402	Sept. 8, 1939	13.0	56.7	1.0	.8	3	do	68	30
Do	495	576	Mar. 1, 1940	12.9	56.5	1.0	1.6	3	Smutty	70	27
Do	495	741	Aug. 13, 1940	12.7	56.7	1.0	.6	3	do		25
Do	495	887	Jan. 6, 1941	12.3	56.7	1.0	.9	3, Light Smutty	do	76	38

BIN F-9—FORCE VENTILATED THROUGH FLOOR, FILLED IN 1938

Average	505	1	Aug. 3, 1938	15.8	56.8	0.7	0	3, Tough	Smutty	74	24
Do	505	32	Sept. 3, 1938	14.8	55.2	1.1	4.6	do	do	58	36
Do	505	59	Sept. 30, 1938	14.6	56.0	1.0	4.4	do	do	60	35
Do	505	213	Mar. 3, 1939	15.0	55.6	.8	4.6	do	do	58	34
Do	505	309	June 7, 1939	14.0	56.6	.8	6.0	3	do	43	40
Do	505	402	Sept. 8, 1939	13.8	56.6	1.1	6.5	3	do	34	45
Do	505	576	Mar. 5, 1940	13.4	56.3	.7	6.3	3	do	40	44
Do	505	741	Aug. 13, 1940	13.1	56.5	.7	6.5	3	Natural		59
Do	505	887	Jan. 6, 1941	13.0	57.1	.8	7.0	3	do	26	57
6 feet above floor [12]		887	do	14.4	56.5	.6	2.0	3	do	30	46
4 feet above floor [12]		887	do	13.4	56.2	.5	.7	3	do	28	
6 inches above floor [12]	505	887	do	11.4	58.6	.2	.2	1	do	96	

[1] All wheat of class Hard Red Spring and subclass Dark Northern Spring.
[2] Trace.
[3] First sample showing abnormal odor. Represents small portion underneath drum, about 6 inches above floor.
[4] Inferior portion amounting to about 40 bushels near the central drum.
[5] Remainder of bin, excluding inferior portion.
[6] Determination of 21.2 units apparently incorrect.
[7] This sample represents about ⅕ of the wheat, near the top of the bin.
[8] This sample represents the remainder of the bin, excluding all inferior wheat.
[9] First sample after wheat was turned. Notice that the mixing of the musty wheat with the unspoiled wheat caused the musty odor to be so slight that it could not be detected.
[10] This sample represents ⅕ of the wheat.
[11] This sample represents the remainder of the wheat, excluding all inferior wheat.
[12] Horizontal probes at indicated levels.

The fan on bin F–5 (wheat moisture 15.4 percent) was operated continuously until noon of December 6, 1937. The wheat was removed from this bin March 21, 1938, at which time it was still in good condition. However, the wheat near the bottom of the bin had a moisture content of 15.2 percent, compared to 14.1 percent for the average of the bin.

The grade data and moisture determinations given in table 7 for bin F–8 are for the wheat after the oats were removed. Most of the moisture loss prior to that time must be attributed to the absorbent action of the oats and not to the ventilating system.

Bins F–6 and F–11 were held for further observation after March 21, 1938, when all other ventilated bins were emptied. The pressure cowl was left in place on F–6 at all times, and was not closed during the winter months. Snow was observed to stop up the vertical duct leading from the cowl to the drum during part of each winter. Part of this snow must have melted and found its way to the wheat by way of the horizontal section of duct, as shown by moisture samples and by the fact that the wheat below the drum developed an abnormal odor by September 8, 1939, after 737 days of storage (see table 7). However, the average sample from the bin did not show an abnormal odor until January 6, 1941, when the moisture content of about 40 bushels of wheat below the drum was 17.8 percent. The wheat had been in storage 1,222 days before turning musty.

Bin F–11 (wheat moisture content 15.6 percent) went through the same storage period (1,222 days) without developing a sour or musty odor in any part of the bin, and on January 6, 1941, was in good condition as far as odor, test weight, and percent damage were concerned, but the loss in germination and increase in fat acidity indicated a quality much lower than in normal wheat.

The performance of ventilated bins F–6 and F–11, in comparison with power-ventilated bins and with unventilated bins, will be discussed in later paragraphs after a presentation of the results of the 1938 tests of ventilation.

The wheat for filling the ventilated bins in 1938 was obtained from combines operating near Fargo and hauled to the bins after being run through a fanning mill. Bins F–7, F–8, and F–9 were filled simultaneously through a divider from truckloads of wheat ranging in moisture content from 14.3 percent to 18 percent, the average being 16.6 percent. The average in each bin after filling was somewhat lower. Bin F–5, with perforated walls and floor, was filled through the divider at the same time as bin F–3, an unventilated metal bin used as a check. These truckloads of wheat ranged in moisture content from 14.6 percent to 16.4 percent.

The changes in quality of the wheat in unventilated check bin F–3 are discussed in detail on page 18. The wheat began to increase in temperature, at a point near the center and 1 foot below the upper wheat surface, immediately after being placed in storage. When the temperature at this point reached 113° F. on August 23, after 20 days in storage, the bin was emptied. The grain in the upper one-fifth of the bin was very musty and had a moisture content when sampled of 15.8 percent, which was well above the average in the bin.

The grain in bin F–5 (perforated walls and floor but no fan), from the same lot as that in bin F–3, also began to rise in temperature near the top center of the bin soon after being placed in storage. When

this temperature reached 105° F., after 26 days in storage, the wheat was moved for cooling and returned to the same bin for further observation. When moved, the wheat in about one-fifth of the bin near the top center was found to be musty and had a moisture content of 16.1 percent. However, after thoroughly mixing with the remainder of the wheat, the odor of the musty portion was not strong enough to be detected. The average moisture content of the wheat dropped about 1 percent during the first year of storage after moving, the greatest amount of drying occurring near the walls. No abnormal odor was noticed until January 6, 1941, 759 days in storage. The musty odor must have developed sometime between that date and the date of the previous sampling, August 13, 1940. The condition of the wheat at the successive sampling periods is shown in table 7.

The wheat temperatures at the centers of bins F–7, F–8, and F–9 were approximately the same in all bins when filled. In bin F–7, having eight horizontal flues, the wheat near the center began to increase rapidly in temperature immediately after filling, reaching 112° F. on August 9, after only 6 days of storage. A point near the bin floor but also in the center increased more slowly to 110° F. after 15 days' storage. When the bin was emptied on August 31, after 29 days in storage, approximately one-fifth of the wheat in the north-central part of the bin was musty and was found to have a moisture content of 19.9 percent. A small area directly on the north wall, near the end of one of the flues, had many sprouting kernels. However, in general, the wheat appeared to be in better condition near the flues. See table 7 for grade factor data.

The blower on bin F–8 was operated for 1 hour each day during the period August 4 to 27, making a total of 24 hours of forced ventilation. The average relative humidity for the 24 days, during the period of ventilation, was 45 percent and the average air temperature 82° F. No measurements were made of the volume of air forced through the grain, but the static pressure in the air drum was about 1 inch water gage. The average wheat moisture content dropped from 15.1 percent on August 3 to 13.4 percent on September 3, a loss of 1.7 percent. Samples taken from various places in the bin showed that the drying rate was greatest near the central drum and lowest at the walls, upper surface, and floor, at which points the air left the wheat. The wheat temperature throughout the bin lowered rapidly at the points where the drying rate was the highest, and no part of the wheat ever showed any indication of heating. It was not necessary to operate the blower again. The grain was still in good condition on January 6, 1941. The average moisture content of the wheat, after the blower was stopped in August 1938 had dropped from 13.4 to 12.3 percent. There was probably a slight movement of air through the grain even without the blower.

The blower on bin F–9 was operated for several hours each day for 41 days during the period August 4 to September 28, 1938. The total hours of operation was 77, during which period the air relative humidity averaged 44 percent and the air temperature 79.5° F. The static pressure in the air chamber averaged about 1.5 inches water gage. No air-volume measurements were made. The average moisture content in F–9 was lowered from 15.8 percent on August 3 to 14.6 on September 30, a loss of 1.2 percent. Drying progressed most rapidly directly over the perforated section of the floor, where the air entered, and the

wheat in this part of the bin cooled rapidly. The wheat away from the inlet showed little drying, and in some locations, especially near the top of the bin, actually increased in moisture content during the first 2 weeks of ventilation. Temperatures away from the inlet locations were not lowered by the ventilating air. The areas near the top of the bin and comparatively close to the walls, not in the direct path of the air, showed a tendency to heat during the first week of storage. Temperatures of 112° were reached near the south and east walls August 5, 1938. Although the static pressure in the air chamber of bin F–9 was higher than in bin F–8, the greater distance the air had to travel through the wheat and the more uneven distribution of air more than offset any advantages of the greater pressure.

The relatively high moisture content near the top of bin F–9 caused no trouble during the winter of 1938–39 but it was thought advisable to operate the blower again for a period the following spring. On April 24, 1939, at which time the wheat moisture content at the upper wheat surface was 16.4 percent, the blower was run for 2 hours, the air having an average relative humidity of 30 percent and a temperature of 74° F. Other runs were made on May 1 and 5, and June 7 and 8, totaling another 10½ hours of blower operation, at an average air temperature of 79° and a relative humidity of 28 percent. The forced ventilation was effective in preventing any heating and reduced the average wheat moisture content from 15 percent, on March 3, to 14 on June 7, 1939, as shown by table 7. At the latest sampling, on January 6, 1941, there was no evidence of abnormal odor in any part of the bin. However, the wheat in the bottom of the bin was in much better condition than in the upper portion.

The same observation may be made regarding the moisture content of wheat stored in ventilated bins as was made in connection with unventilated bins—namely, that the length of the safe storage period is not determined by the average wheat moisture content unless the moisture is quite uniformly distributed throughout the bin, but by the highest moisture content in any part of the bin. For instance, in 1937, uniform moisture content wheat at 15.6 percent was placed in bin F–11, ventilated with horizontal screen tubes, and this wheat had been in storage 1,222 days on January 6, 1941 without developing an abnormal odor. A bin with a similar type of ventilating system, F–7, was filled in 1938 with wheat averaging slightly lower in moisture content (15.4 percent); but because some of the wheat had a moisture content over 18 percent the entire lot developed a musty odor in 29 days.

Comparison of Ventilated and Unventilated Bins

Two large unventilated bins, F–1 and F–2 (1937), two naturally ventilated bins F–6 and F–11 (1937), and two force-ventilated bins F–8 and F–9 (1938), were left in storage at Fargo for a long enough period that some conclusions can be drawn as to the benefits of ventilation. In figure 13 are shown the lengths of time the wheat was stored in each bin until the first indication of abnormal odor was observed, and the length of time until the entire lot was out of condition, or was disposed of before going out of condition, or is at present still in storage without abnormal odor. The unshaded bars indicate the bins falling into this latter classification.

It is apparent that bin F–6, with the pressure cowl forcing air into a central drum, was more effective in storing wheat containing 15.8 percent of moisture than unventilated bins in storing wheat containing 14.2 and 14.5 percent of moisture. The failure of bin F–6 to store the wheat for an even longer period can be ascribed to the fact that snow, entering through the air ducts, raised the wheat moisture content to a dangerous level. This could be remedied by a better design of the cowl or the duct system leading to the drum, so that snow would be excluded, or by more careful operation of dampers during the winter. The horizontal flues in bin F–11 with protective caps on the ends, while drying the wheat at a slower rate during the early storage period did not allow snow to enter the bin in large

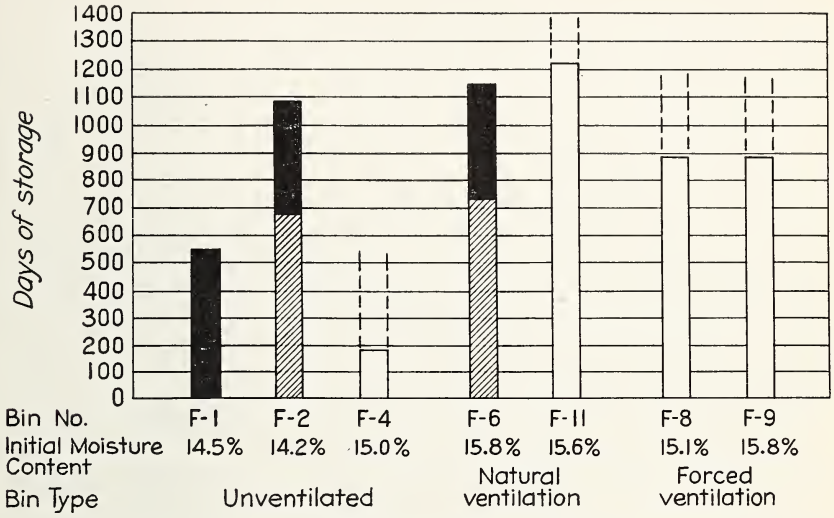

FIGURE 13.—Time in storage in ventilated and unventilated bins in North Dakota before wheat developed abnormal odor. Shaded section of bars indicates time until first abnormal odor was observed in any part of the bin and solid bars time until wheat in entire bin showed abnormal odor. Unshaded bars indicate bins in which wheat was disposed of before going out of condition or in which wheat is still in storage in good condition.

quantities and therefore have resulted in a relatively long safe-storage period for the wheat.

The wheat stored in force-ventilated bins F–8 and F–9 presented a much more difficult storage problem than that stored in F–6 and F–11, as was evidenced by the fact that the wheat in flue-ventilated bin F–7 (1938) from the same lot went rapidly out of condition.

Although the ventilated bins successfully stored wheat with an initial moisture content higher than can safely be stored in unventilated bins, it should be remembered that this was because the ventilation systems removed the excess moisture and dissipated any heat from the respiration of the kernel and microorganisms before the wheat was damaged. As shown by the curves in figure 14, the average moisture content of the wheat in all bins, both ventilated and unventilated, after the first year of storage was below 14.5 percent, and

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after 2 years of storage, below 13.5 percent in the ventilated bins. The curves cover the period until the average sample showed an abnormal odor, or until the latest sampling, if the wheat was still in good condition. The broken line section of the curve indicates the period after the first abnormal odor was observed in any part of the bin before it was observed in the average sample. The more rapid

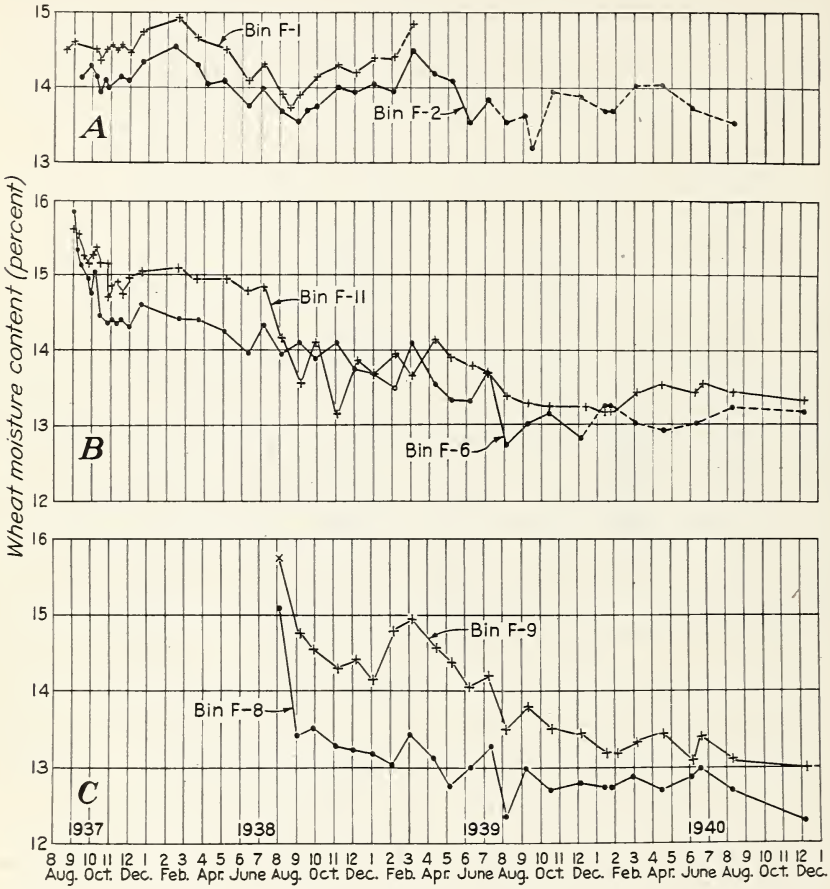

FIGURE 14.—Average wheat moisture content in ventilated and unventilated bins at Fargo. *A*, Unventilated bins; *B*, natural and pressure ventilated bins; *C*, power ventilated bins. Solid lines represent period before first abnormal odor was observed, broken lines period until entire bin graded Sample because of abnormal odor.

drying obtained by the use of power ventilation (fig. 14, *C*) during the first period of storage should be noted.

The rate of deterioration as measured by percent germination is shown for the same bins in figure 15. The difference in germination of wheat of two moisture contents stored in unventilated bins F–1 and F–2 is more marked than the difference in odor. After 1 year

of storage the germination had dropped 5 percent in the 14.2 percent-moisture wheat (F–2) and 20 percent in the 14.5-percent-moisture wheat (F–1). When the first abnormal odor was observed in bin F–1 the germination had dropped 48 percent as compared to only 11 percent in bin F–2 at the same time. The germination loss of the wheat stored in the naturally ventilated bins F–6 and F–11 and the force-ventilated bin F–8 averaged somewhat less than in the wheat

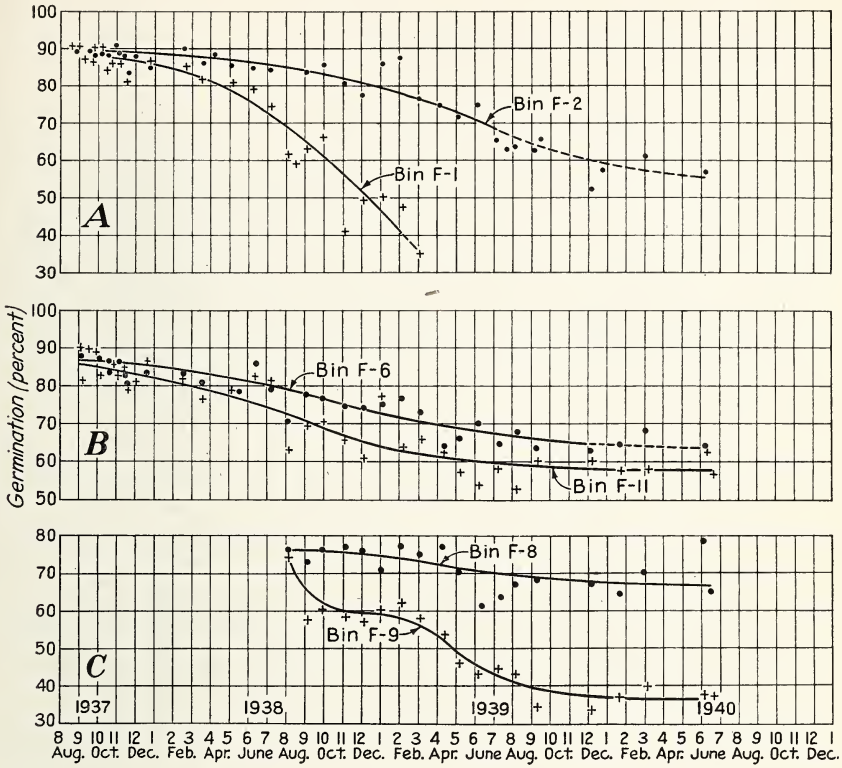

FIGURE 15.—Germination-percentage changes in wheat stored in ventilated and unventilated bins at Fargo. *A*, Unventilated bins; *B*, natural- and wind-pressure ventilated bins; *C*, power-ventilated bins. Solid lines represent period before first abnormal odor was observed, broken lines period until entire bin graded Sample because of abnormal odor.

having 14.2 percent moisture stored in unventilated bin F–2. The loss in bin F–9 was much greater, the periods of high moisture content when it was necessary to operate the blower being very apparent. However, as shown in table 7, the germination loss at the bottom of the bin, where the wheat was dried quickly, was small.

In making conclusions as to the adequacy of any structure for safely storing wheat in a locality, the variation of the weather from normal during the test period, must be considered. As shown in figure 16, the average temperature in summer during the period of this investigation was consistently higher than normal, and the relative humidity

was consistently lower. The air temperature influences the temperature of wheat stored in both ventilated and unventilated bins. On the other hand, the relative humidity of the air has little effect on the moisture content of wheat stored in unventilated bins but combined with temperature, is a controlling factor in ventilated storages where the problem is to dry the grain quickly. As the air temperature during the period of the tests discussed herein was usually higher than normal, it is probable that the results of the tests with unventilated bins in North Dakota can be safely applied in most years. However, since the relative humidities during the same period were lower than

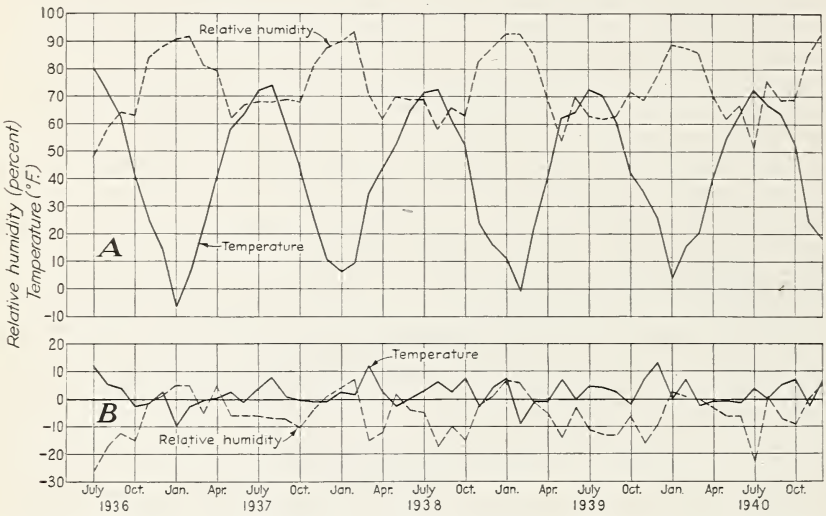

FIGURE 16.—Average monthly air temperature and percentage of relative humidity (*A*), and variation of temperature and percentage of relative humidity from the normal (*B*) for Fargo, from July 1936 to December 1940.[5]

normal, especially during the early storage period, the results of the tests of ventilated bins might not be applicable in all years, or even in a normal year.

WHEAT STORAGE IN KANSAS

The tests in Kansas were conducted at Hays, in the west central section of the State, where the facilities of the Fort Hays branch experimental station were available. The studies reported by the Kansas Agricultural Experiment Station (*7*) were made at this station in 1929, 1930, and 1931. The station each year loaned several thousand bushels of wheat for experimental use and the technical staff advised and assisted in the work.

In figure 17 is shown a general view of the experimental bins at Hays, Kans.

[5] Records for Moorhead, Minn., directly across Red River from Fargo, are from U. S. Weather Bureau Bulletin W.

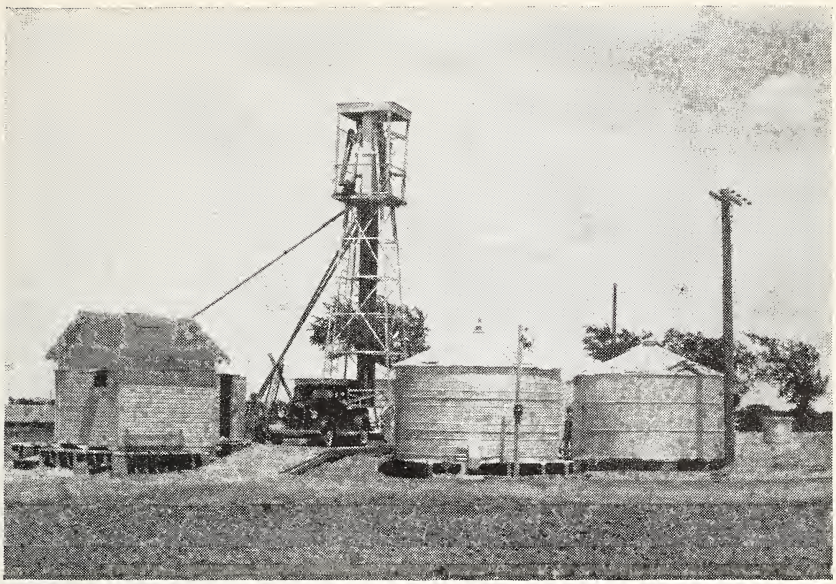

FIGURE 17.—General view of experimental bins at Hays. Note elevator and grain divider.

Moisture Limits for Safe Storage in Western Kansas

The Official Grain Standards of the United States provide that the maximum wheat moisture content allowable for hard red winter wheat of the numerical grades is 14 percent unless the word "Tough" is added to the grade designation, except that if the wheat moisture content is above 15.5 percent the wheat is designated Sample grade. These limits are one-half percent lower than those for hard red spring wheat, but the studies discussed herein indicate that they are nevertheless too high to be considered as the safe maximum moisture content for storage on the farm.

The object of the tests with large bins at Hays in 1936 was to determine the effect of bin size, material of construction, and ventilation on the keeping quality of wheat. Tests for the determination of the maximum safe moisture content were made only in small 20-bushel bins. However, because the wheat used in these 1936 tests with large bins, combined locally, varied greatly in moisture content, ranging from 10 to 18 percent, and was not thoroughly mixed before storage, it is possible to observe the effect of uneven moisture distribution on storage. The wheat, as it came from the combine, was elevated directly from the trucks to the bins, through a grain divider, without mixing, resulting in layers of damp and dry grain. The grain divider insured that each bin in a group had the same kind of wheat, with about the same moisture distribution. Four 500-bushel (H–1, H–2, H–3, and H–4) and one 1,000-bushel (H–7) unventilated bins were filled with wheat having these ranges of moisture. Bins H–1 and H–7 were of all-metal construction, differing only in size, H–1 being 10 feet in diameter and H–7, 14 feet. Both had 8-foot

walls. Bin H–2 was also metal but its sides were insulated on the inside with ½-inch insulation board laid on 1- by 2-inch vertical furring strips spaced 7 inches on centers. Bin H–3 was of wood construction, with single walls of 1- by 8-inch shiplap siding, floor of 1- by 4-inch tongue-and-groove boards, and roof of 1- by 8-inch shiplap covered with uncoated asphalt roofing. The building measured 10 by 10 feet to the outside of the studs, with 8-foot walls. Bin H–4 was of concrete staves with concrete floor and wood roof. Its diameter was 10 feet to the outside of the staves, which were 3 inches thick.

The weather during harvest was very hot, resulting in wheat going into the bin with temperatures well over 100° F. Because of the high air and initial wheat temperatures, and the layers and spots of wheat having very high moisture content, the wheat in all five of the unventilated bins increased steadily in temperature and it was necessary to move it a few days after storage. The initial and final grade factor data and other pertinent information are given for each bin in the general tables in the appendix, page 166. As the wheat in the four 500-bushel bins reacted in almost the same manner, only metal bin H–1 and the 1,000-bushel metal bin H–7 will be discussed here in detail. The grade data throughout the short storage period are shown for both bins in table 8. Samples taken from bin H–1 at the time of filling showed that the wheat moisture content in the bottom half of the bin averaged 13.2 percent and in the top half 12.0 percent, with an average for the bin of 12.5 percent. Ten days later from 50 to 75 bushels near the bottom of the bin was heating and had a slightly sour odor. The moisture content of this inferior portion averaged 14.4 percent. Three days later, on July 11 (see table 8) this inferior portion had increased in size to approximately 150 bushels, with a moisture content of 15.0 percent. Mixing of the wheat by elevating to another bin and back again was not sufficiently thorough to make the moisture content uniform at 12.2 percent (the observed average for the bin) and deterioration had progressed to such a degree before mixing that the entire lot of wheat was sour by July 27.

The wheat in the 1,000-bushel bin, H–7, containing 780 bushels from the same lot underwent much the same reactions during its short storage period, as shown by the grade data from successive samples in table 8. The average moisture content of the wheat was 12.8 percent but the moisture content of the portion that first developed an abnormal odor was 14.4 percent.

The history of a lot of wheat (782 bushels) placed in storage in a ventilated bin in 1936 is of interest because it was later moved to an unventilated bin and has remained in good condition for over 4 years. The wheat was first placed in bin H–5, a round metal 1,000-bushel bin 14 feet in diameter and 8 feet high. Ventilation was provided through a floor of fly screening laid on an angle-iron grid and through a protected opening in the bin roof. The initial average moisture content was 12.3 percent. Although no samples were taken from different parts of the bin, it is safe to assume that the moisture content varied as much as it did in the unventilated bins since it was from the same source. The wheat was left in storage until November 25 (151 days after filling) when it was moved in order to weigh it and then returned where it remained until July 7, 1938. At this time, after

TABLE 8.—*Grade data, quantity, and time in storage for wheat stored in unventilated bins at Hays in 1936*

Sample type	Quantity of wheat	Time in storage	Date	Wheat moisture content	Test weight per bushel	Dockage	Damage	Grade [1]	Odor	Germination	Fat acidity
	Bushels	*Days*		*Percent*	*Pounds*	*Percent*	*Percent*			*Percent*	*Units*
BIN H-1—METAL WITH METAL FLOOR											
Average [2]	502	1	June 29, 1936	12.5	54.8	0.9	1.0	4	Natural		
Top of bin [3]	251	1	do	12.0	56.0	.7		3	do		
Bottom of bin [4]	251	1	do	13.2	53.5	1.0		5	do		
Average	502	4	July 2, 1936	12.2	55.7	.7		4	do		
Inferior [5]	50–75	10	July 8, 1936	14.4	52.0	1.0	1.7	Sample	Slightly sour		
Remainder [6]	427–452	10	do	12.1	55.7			4	Natural [7]		
Inferior [5]	150	13	July 11, 1936	15.0	51.7	1.8	3.0	Sample	Slightly sour		
Remainder [6]	352	13	do	11.8	55.5			4	Natural [7]		
BIN H-1—AFTER MOVING ON JULY 11, 1936											
Average	502	1	July 12, 1936	12.2	55.3	0.6	1.0	4	Natural		
Do	502	6	July 17, 1936	12.0	55.3	.7		4	do		
Inferior [5]	65	11	July 22, 1936	14.7	54.0	.6		Sample, Tough	Slightly sour		
Remainder [6]	437	11	do	11.9	55.5			4	Natural		
Average [8]	502	16	July 27, 1936	12.2	54.7	.6		Sample	Sour		
BIN H-7—METAL WITH METAL FLOOR (BEFORE MOVING)											
Average [2]	780	1	June 27, 1936	12.8	55.5	1.1	2.0	4	Natural	86	[9] 9
Do	780	3	June 29, 1936	12.7	55.5	.9		4	do		
Do	780	6	July 2, 1936	12.6	55.5			4	do		
Do	780	10	July 6, 1936	12.4	55.7	.8		4	Slightly heating		
Inferior [10]	30	12	July 8, 1936	14.4	52.4	1.2	2.0	Sample, Tough	Slightly sour		
Remainder [6]	750	12	do	12.8	55.5			4	Natural		
Inferior	50	14	July 10, 1936	14.4	51.8	1.4	3.5	Sample, Tough	Slightly sour		
Remainder	730	14	do	12.5	55.7			4	Natural		
Inferior [11]	125	17	July 13, 1936	15.2	50.5	3.2	15.0	Sample, Tough	Slightly sour		
Balance [11]	655	17	do	12.8	55.7			4	Natural		

See footnotes at end of table.

TABLE 8.—*Grade data, quantity, and time in storage for wheat stored in unventilated bins at Hays in 1936*—Continued

Sample type	Quantity of wheat	Time in storage	Date	Wheat moisture content	Test weight per bushel	Dockage	Damage	Grade	Odor	Germination	Fat acidity
	Bushels	*Days*		*Percent*	*Pounds*	*Percent*	*Percent*			*Percent*	*Units*
BIN H-7—AFTER MOVING ON JULY 13, 1936											
Average	780	0	July 13, 1936	12.3	56.7	0.6	1.5	3	Natural		
Do	780	14	July 27, 1936	11.8	55.4	.7		4	do		
Do	780	18	July 31, 1936	12.2	56.2	.7		3	do		
Do.[8]	780	25	Aug. 7, 1936	12.4	55.7	.6		Sample	Sour		
BIN H-5—METAL WITH SCREEN FLOOR											
Average	782	0	June 27, 1936	12.9	56.0	1.1	1.8	3	Natural	85	[9] 9
Do	782	151	Nov. 25, 1936	11.4	56.4	1.3	2.0	3	do		
WHEAT MOVED FOR WEIGHING AND RETURNED TO H-5											
Average	782	248	Mar. 2, 1937	11.7	56.5	0.5	1.4	3	Natural		
Do	782	550	Dec. 29, 1937	11.1	54.7		1.0	4	do	78	17
WHEAT MOVED TO UNVENTILATED BIN H-8 ON JULY 7, 1938											
Average	782	740	July 7, 1938	11.3	56.1	0.5	0	3	Natural	63	20
Do	782	1,130	Aug. 1, 1939	11.5	55.7	.5	1.0	4	do	76	22
Do	782	1,501	Aug. 7, 1940	11.7	55.4	.5	.5	4	do		
Do	782	1,663	Jan. 16, 1941	11.5	56.1	.6	2.0	3	do		

[1] All wheat of class Hard Red Winter and subclass Dark Hard Winter.
[2] Average for entire bin.
[3] Average for top half of bin.
[4] Average for bottom half of bin.
[5] Inferior portion near bottom of bin.
[6] Remainder of bin, excluding all inferior wheat.
[7] Heating.
[8] First average sample having abnormal odor.
[9] Fat acidity calculated from acid value determination and average oil content of hard red winter wheat.
[10] Inferior portion at center of bin.
[11] These were last samples taken before the bin was emptied and turned for mixing and cooling. There were heating and slightly sour spots through the bin center 1 foot from top, extending down 4 or 5 feet and spreading out toward the sides.

740 days of storage since the original filling date, the wheat was moved to an unventilated 1,000-bushel metal bin, H–8. On May 31, 1939, a moldy and musty spot of wheat was discovered on the north side of the bin, near the upper surface, and directly beneath a filling door. The spot at that time was about 3 feet in diameter and 2 feet deep. When average samples were taken, this spoiled wheat was not included as it was in the average samples at Fargo. On January 16, 1941, when it had been in storage since the original filling date in 1936 for 1,663 days, or more than 4½ years, the wheat was still in very good condition.

If only the time after the wheat was placed in the unventilated bin H–8, is considered, the total storage period until the latest sampling January 16, 1941, was 923 days, and until the first musty odor was noticed on May 31, 1939, 328 days. The average moisture content for the 923 days was 11.5 percent.

All of the 1936 large bins except bin H–5, were remodeled and renumbered for the 1937 experiments. Each bin was divided by a wooden partition on the north-south center line. Bins H–1–W and H–1–E were the west and east halves, respectively of 1936 bin H–1, a 500-bushel metal bin. The insulation lining was removed from H–2 (500-bushel metal bin) and a center partition installed, making two bins, H–2–W and H–2–E, the west and east halves, respectively. Only the west half of 1936 wood bin H–3 was used, renumbered H–3–W. The concrete-stave bin was also divided and renumbered H–4–E and H–4–W.

The wheat stored in the experimental bins in 1937 was shipped by rail from Enid, Okla., this method of handling resulting in a much more even distribution of moisture throughout the bins than was obtained in 1936. The initial wheat temperature was also lower, averaging below 90° F. The average moisture content (percent) of the wheat placed in the various bins was as follows: 13.4 in H–1–W, 14.4 in H–2–W and H–3–W, 14.8 in H–4–W, and 15.3 in H–1–E, H–2–E, and H–4–E. The two latter bins are discussed under Use of Fungicides, Insecticides, and Absorbents in Farm Wheat Storage on page 119 as straw was mixed with the wheat when the bins were filled. Grade data and days in storage for the five untreated wheat bins are given in table 37 in the appendix. All of the wheat having a moisture content over 15 percent was sour after 16 days in storage, and that between 14 and 15 percent in approximately 40 days. The only wheat not developing an abnormal odor during the experimental storage period was that in bin H–1–W, having an initial moisture content of 13.4 percent. However, the wheat was disposed of on September 13, 1937, before going out of condition. During the 68 days of storage the germination in this bin dropped 16 percent and the fat acidity increased 6 units.

Only one large unventilated bin, H–2, was filled in 1938 with wheat harvested the same year. This was a metal bin having a capacity of 500 bushels. Wheat combined on the experiment station farm was used, averaging 10.2 percent when stored. Although the bulk of the wheat ranged from 8.5 to 10.5 percent of moisture, there were small quantities having as high as 15 percent. The wheat was left in storage from July 8, 1938, until November 2, 1939, a period of 482 days, before being disposed of, during which it deteriorated very little as shown by the initial and final samples in table 37 of the appendix.

No experimental unventilated bins were tested at Hays in 1939,

but a survey was made in which 47 farm bins scattered over the State were sampled in July after the wheat had been in storage from 2 to 41 days, the greatest number between 20 and 30 days. Of the 8 bins containing wheat with moisture contents over 14.0 percent at the time of sampling, 3 were either sour or musty. A second survey was made of 22 of the bins in the latter part of September, after approximately 90 days of storage. Wheat in 8 of this group of 22 bins averaged over 13 percent moisture at the first sampling, and at the second sampling (after about 90 days' storage) the wheat in 5 of the 8 bins was either musty or sour. Of the 3 bins with wheat having over 13 percent moisture which did not develop an abnormal odor, 1, K–23, had lowered 2 numerical grades, increased from 1 to 10 percent in total damage, and decreased 30 percent in germination; the wheat in the second bin, K–31, had lowered from 13.5 to 11.8 percent in moisture content, due to frequent moving and turning; and the wheat in the third bin, K–40, was moved at least twice during storage. The most commonly observed storage hazard in the survey was alternate layers of dry and damp grain, most of the wheat having been harvested by combine.

The grade data from the first and second sampling of all the Kansas 1939 survey bins as well as other information are given in table 44 of the appendix. This group of bins are numbered K–1 to K–48.

The results of the Kansas tests and farm survey insofar as the maximum moisture content for safe storage is concerned may be summarized as follows:

1. Storage of wheat with an average moisture content over 12.5 percent in unventilated bins is not safe if the wheat is uneven in moisture content as may be the case if the grain is harvested by combine. This was illustrated very well under actual farm conditions by a survey made in 1939 and by tests at the Hays station in 1936.

2. If the bin is weathertight, wheat of 11.8 percent moisture content can be stored safely for at least 2½ years.

A comparison of ventilated and unventilated bins as to the safe wheat moisture content for various storage periods is made on page 57.

Small-Bin Storage at Hays

A group of 10 small bins of 20-bushel capacity, were filled at Hays in 1936. Five were of plain metal construction 40 inches in diameter and 36 inches high; 5 were insulated with 3 inches of rock wool placed between two metal shells, the inside shell also being 40 inches in diameter and 36 inches high and serving as a container for the wheat. Two of the bins, H–17 and H–18, were used in tests with straw as an absorbent, and are discussed on page 126. The remaining 4 plain metal bins were numbered H–9, H–11, H–13, and H–15, and the insulated bins H–10, H–12, H–14, and H–16. The wheat used for filling the small bins was combined and rather uneven in moisture content. The bins were arranged in pairs, 1 insulated and 1 uninsulated, and each pair filled with approximately the same moisture content wheat, the different pairs ranging from 12 percent to 18 percent. The moisture content and quality of the wheat placed in each bin are given in table 37 of the appendix.

The small bins were sampled on November 26, 1936, 96 days after storage, when the wheat in all bins was sour. No comparison can, therefore, be made of the effect of moisture content, bin size, and type

on the length of storage possible before abnormal odors develop. It is evident, however, that insulating the bins did not prevent deterioration. The small insulated bins were warmer at the center at the end of the 96 days than the uninsulated bins, the difference being much more pronounced at the higher moisture contents.

No large unventilated bin was left in storage for 96 days without moving, to afford a comparison on the performance of the small bins. However, by comparing the moisture, temperature, germination, and damage changes observed in large screen-bottom ventilated bin H–5 and each of the small bins, some differences may be observed between the different sizes, bin types, and wheat moisture contents. Such a comparison is made in table 9 for the 96-day period. The outstanding difference, of course, between the large ventilated bins and the small bins was that the wheat in the large bin did not develop an abnormal odor while that in the small bins did without exception.

TABLE 9.—*Comparison of quality of wheat after 96 days' storage in large ventilated bins and small plain metal and insulated bins at Hays in 1936*

Item	H–5. Ventilated	H–9. Plain metal	H–10. Insulated metal	H–11. Plain metal	H–12. Insulated metal	H–13. Plain metal	H–14. Insulated metal	H–15. Plain metal	H–16. Insulated metal
Bin capacity, bushels	1,000	20	20	20	20	20	20	20	20
Initial wheat moisture, percent	12.9	12.0	11.8	13.5	11.8	14.6	14.5	17.8	18.1
Final wheat moisture, percent	12.0	12.6	12.4	13.6	12.6	15.0	15.0	15.9	14.6
Initial wheat temperature, ° F.[1]	105	116	115.	117	117	110	112	115	115
Final wheat temperature, ° F.[1]	68	65	72	68	76	70	86	73	90
Increase in total damage, percent	1.0	−0.2	−1.7	1.8	−0.1	23.7	69.6	83.2	84.0
Decrease in germination, percent	4	0	2	50	30	66	48	55	61
Odor after 96 days' storage	Natural	Sour	Sour	Sour	Sour	Sour	Sour	Sour	Sour

[1] At bin center.

Fourteen of the 20-bushel bins were filled at Hays in 1937, the bin numbers and the initial and final quality of the wheat for each bin being given in table 37 of the appendix. Two of the plain metal bins, H–25 and H–26, were filled with wheat very similar in moisture content to that stored in two of the large bins, H–1–W and H–4–W. Bin H–1–W was the west half of a 500-bushel round metal bin and H–4–W the west half of a 500-bushel concrete bin described previously on page 38. Wheat of approximately 13 percent moisture content was placed in bins H–1–W and H–25, and of about 14.8 percent in bins H–4–W and H–26. The length of time each bin was under observation before an abnormal odor was noticed in the wheat is given in table 10. The period of safe storage was decidedly greater in the small bins in both moisture-content groups and the average wheat-moisture content was slightly lower. The change in condition of the wheat as indicated by germination decrease and fat-acidity increase at the time the first bin in each pair first developed an abnormal odor is also shown. This was at 68 days after storage for bins H–1–W and H–25, and 41 days after storage for bins H–4–W and H–26. The germination decrease was 30 percent more in the 250-bushel bin, H–4–W, than in small bin H–26 in the 41-day period. In bin H–1–W

it was 38 percent greater than in H–25, in the 68-day period. In this latter case, however, the average wheat moisture content of the small bin was 0.5 percent lower than in the larger bin.

TABLE 10.—*Days in storage before developing abnormal odor and changes in wheat quality observed in bins of two sizes filled at Hays, in 1937*

	Data for wheat in bin Nos. —			
	H–1–W	H–25	H–4–W	H–26
Bin capacity ..... bushels	250	20	250	20
Initial wheat moisture ..... percent	13.4	12.9	14.8	14.7
Period before developing abnormal odor ..... days	68	403	41	76
Change in quality of wheat during storage at time when large bin of each pair developed abnormal odor:				
Germination decrease ..... percent	16	10	57	40
Fat-acidity increase ..... units	6	5	9	10

VENTILATION OF BINS (3)

The weather conditions of western Kansas are usually very favorable for drying wheat by bin ventilation. Monthly mean relative humidities at noon range from 43 to 56 percent during normal years, with the higher humidities in the winter, but during harvest and the early storage period relative humidities of 10 to 20 percent occur frequently. Monthly wind velocities range from 5 to 14 miles per hour with a mean of approximately 10 miles per hour. Many different types of ventilating systems were tested at Hays to find the best method of taking advantage of these weather conditions.

1936 TESTS

Three 1,000-bushel, round, steel bins were used in 1936 to check various methods of ventilation. These bins were all 14 feet in diameter and 8 feet high to the plates, and had conical steel roofs (fig. 18). Bin H–5 was described previously on page 38. It had a floor of fly screening laid on an angle-iron grid and a ventilator in the bin roof. This ventilator was not of the suction type but was merely a protected opening. The walls were tight. Bin H–6, the same size and shape as H–5, had a tight metal floor and perforated metal walls, and was fitted with a vertical galvanized flue 20 inches in diameter in the bin center, connected at the upper end to a suction-type cowl kept pointed away from the wind by a vane. The bottom part of the flue was perforated to within a short distance of the upper wheat surface with a number of small holes, spaced 1¼ inches on centers and approximately ⅙ of an inch in diameter, with a total area of about 0.2 percent of the flue area. The ventilating air could enter the wheat through the perforated walls, pass through approximately 6 feet of grain, and pass out through the suction cowl by way of the vertical flue, or through some portion of the perforated wall.

The only power-ventilation system tested was in bin H–8, a 1,000-bushel, round metal bin with tight walls and floor. Air could be forced into the wheat through five 1¼-inch sand-point-tipped pipes extending 1 inch above the floor—one in the center and four equally spaced 4 feet 3 inches about the center. The blower used was of the positive displacement gear type, driven by a ½-horsepower electric motor.

Bin H–7, exactly the same size and shape as the three just described, but having no ventilation, was used as a check bin.

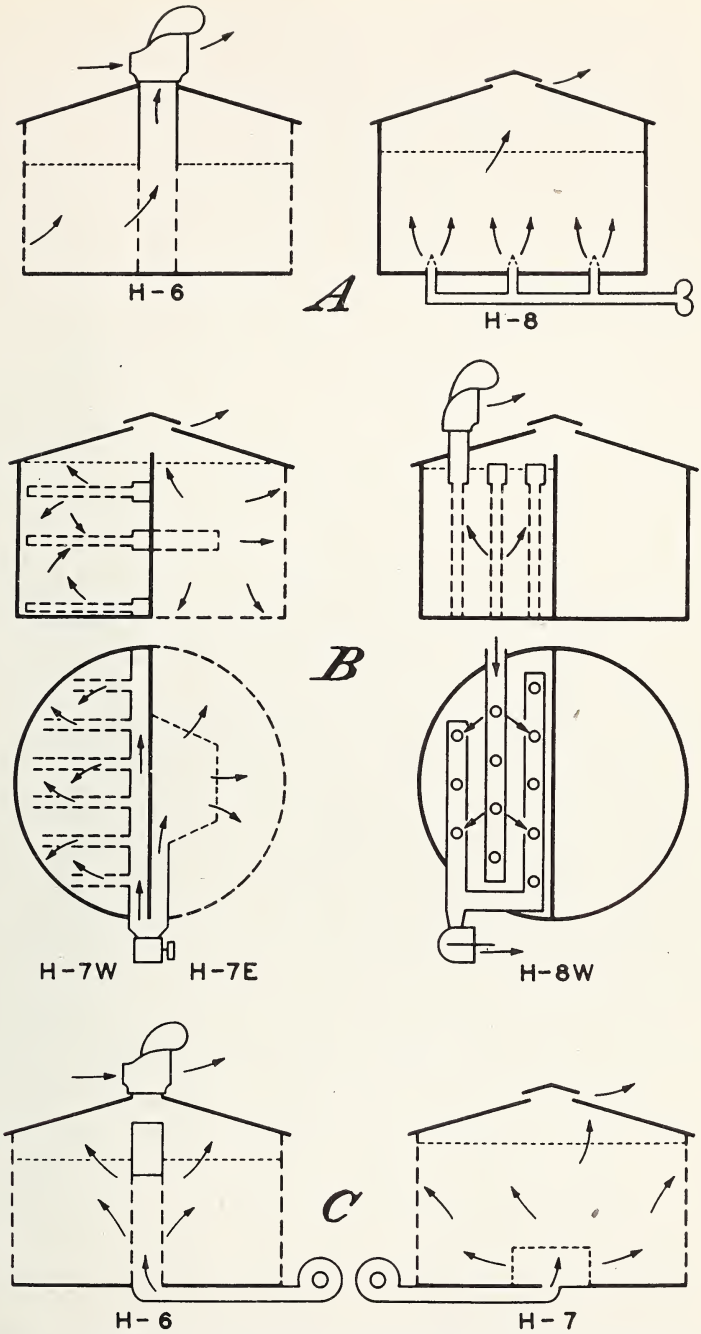

FIGURE 18.—Diagram of several of the ventilated bins used at Hays: *A*. 1936; *B*, 1937; *C*, 1938

Grain was delivered directly to the experimental bins from combines operating in the vicinity. While attempts were made to harvest grain that contained between 14 and 15 percent of moisture as was explained previously on page 37, the moisture content of the various truckloads varied greatly, some being as low as 10 percent and some as high as 18. The higher-moisture-content grain had many green and immature kernels. Each truckload was divided about equally among the four bins (H–5, H–6, H–7, and H–8) by means of a divider so that, although all bins had approximately the same kind and moisture content of wheat, the wheat in each bin had layers of damp and dry grain.

The four bins were filled on June 25 and 26, and the first average samples were taken within a day or two. No samples were taken at this time to locate the wet layers in the bins. In table 11 are given the grade data, days in storage, and other information, for each bin at the successive sampling dates.

The temperature in the center of the unventilated check bin H–7 increased steadily from 111° to 127° F. in 10 days, then decreased to 122° on July 8, when, after 12 days in storage, an area in the center amounting to 25 to 30 bushels was found to be slightly sour and out of condition.

The wheat in bin H–5, with the screen floor, from the same lot of wheat as in H–7, decreased in 2 weeks from a temperature of 105° F. in the center to 77°. The average moisture also dropped about 1 percent in the same period, and there was probably additional benefit derived from transfer of moisture from wet layers to dry layers, resulting in a more even moisture content throughout the bin. The wheat in bin H–5 was left in storage until November 25, 1936, when it was moved in order to weigh it, and then returned to the same bin where it remained until July 7, 1938. Numerous samples taken during the storage period indicated that the wheat was always in good condition. As explained on page 38 the wheat was then transferred to an unventilated bin, H–8, for further observation.

Bin H–6, with perforated walls and central flue connected to a suction cowl, was filled with wheat averaging 13 percent of moisture, but varying greatly in the bin, and having an initial high wheat temperature in the center, a few inches from the flue, of 113° F. This point, always the warmest in the bin, dropped to 102° by July 6, after 10 days in storage, but at that time the wheat in the same area, amounting to 10 to 15 bushels, developed a sour odor. When the bin was emptied the wheat next to the central flue and in the wet layers was somewhat caked. It should be noted that the heating wheat had a moisture content higher than the bin average (table 11).

The power-ventilated bin, H–8, filled with wheat averaging 13.1 percent moisture content, but also varying greatly from one level to the next, was filled on June 26 with 780 bushels of wheat from the same source as that used in the other bins. The blower was started immediately, and was operated continuously for 10 days. The average moisture content of the wheat was lowered in the 10 days, from 13.1 percent to 12.2 percent. As only average samples were taken it is not known if the wheat dried uniformly or how much the high-moisture levels were reduced by transferring moisture to the drier areas.

TABLE 11.—*Grade data, days in storage, and quantity of wheat stored in ventilated bins at Hays, in 1936, 1937, 1938, and 1939*

Sample type	Quantity of wheat	Time in storage	Date	Wheat moisture content	Test weight per bushel	Dockage	Damage	Grade [1]	Odor	Germination	Fat acidity
	Bushels	*Days*		*Percent*	*Pounds*	*Percent*	*Percent*			*Percent*	*Units*
H-7 (UNVENTILATED CHECK BIN) STORED IN 1936											
Initial	780	1	June 27, 1936	12.8	55.5	1.1	2.0	4	Natural	86	[2] 9
Inferior [3]	780	12	July 8, 1936	14.4	52.4	1.2	2.0	Sample, Tough	Slightly sour		
Remainder [4]	750	12	July 8, 1936	12.8	55.5			4	Natural		
Inferior [5]	125	17	July 13, 1936	15.2	50.5	3.2	15.0	Sample, Tough	Slightly sour	2	[2] 28
Remainder [4]	655	17	do	12.8	55.7			4	Natural	64	[2] 13
BIN H-5 (TIGHT WALLS, SCREEN FLOOR) STORED IN 1936											
Initial	782	1	June 27, 1936	12.9	56.0	1.1	1.8	3	Natural	85	[2] 9
Average	782	152	Nov. 25, 1936	11.4	56.4	1.3	2.0	3	do		
WHEAT MOVED FOR WEIGHING, STORED IN 1936											
Average	782	249	Mar. 2, 1937	11.7	56.5	0.5	1.4	3	Natural		
Last	782	741	July 7, 1938	11.1	54.7		1.0	4	do	78	17
BIN H-6 (TIGHT FLOOR, PERFORATED WALLS, CENTRAL PERFORATED FLUE, AND SUCTION COWL) STORED IN 1936											
Initial	739	1	June 27, 1936	13.0	55.3	1.3	1.6	4	Natural	80	[2] 9
Inferior [6]	15	10	July 6, 1936	13.3	51.0	1.8	7.0	Sample	Sour		
Do [7]	30	14	July 10, 1936	14.6	53.3	1.7	4.0	Sample, Tough	Slightly sour		
Do [8]	100	17	July 13, 1936	15.4	48.5	4.0	10.0	do	Musty	11	[2] 18
Remainder [4]	639	17	do	11.8	55.4			4	Natural	82	[2] 11
BIN H-8 (FORCED VENTILATION THROUGH 5 FLOOR OPENINGS) STORED IN 1936											
Initial	780	1	June 27, 1936	13.1	55.7	1.0	1.8	4	Natural	90	[2] 8
Average [9]	780	95	Sept. 29, 1936	11.6	55.7	.6	2.0	Sample	Sour	88	[2] 13
Last	780	152	Nov. 25, 1936	11.7	55.7	1.2	1.9	do	do		

See footnotes at end of table.

TABLE 11.—*Grade data, days in storage, and quantity of wheat stored in ventilated bins at Hays, in 1936, 1937, 1938, and 1939*—Con.

Sample type	Quantity of wheat	Time in storage	Date	Wheat moisture content	Test weight per bushel	Dockage	Damage	Grade [1]	Odor	Germination	Fat acidity
	Bushels	*Days*		*Percent*	*Pounds*	*Percent*	*Percent*			*Percent*	*Units*
BIN H-1-E (UNVENTILATED CHECK BIN) STORED IN 1937											
Initial	230	1	July 1, 1937	15.4	61.1	0.3	0	1, Tough	Natural	71	20
Final	230	13	July 13, 1937	15.0	59.4		4.0	Sample, Tough	Slightly musty	45	24
BIN H-10 (BOTTOM VENTILATION, 4 FEET WHEAT DEPTH) STORED IN 1937											
Initial	64	1	July 2, 1937	15.2	61.1	0.2	0.2	1, Tough	Natural	70	20
Average	64	7	July 8, 1937	15.1	60.3		.2	do	do	55	22
Do	64	12	July 13, 1937	15.0	59.4		.3	2, Tough	do	38	24
Final	64	15	July 16, 1937	15.5	58.2		5.0	Sample, Tough	Musty	16	33
BIN H-11 (BOTTOM VENTILATION, 6 FEET WHEAT DEPTH) STORED IN 1937											
Initial	96	1	July 2, 1937	15.8	61.2	0.2	0	Sample	Natural	71	21
Average	96	6	July 7, 1937	15.4	60.6		.4	1, Tough	do	60	22
Do	96	12	July 13, 1937	15.0	59.3		.3	2, Tough	do	32	22
Final	96	19	July 20, 1937	14.9	59.0		.1	Sample, Tough	Musty	25	32
BIN H-12 (BOTTOM VENTILATION, 8 FEET WHEAT DEPTH) STORED IN 1937											
Initial	128	1	July 2, 1937	15.2	61.6	0.1	0	1, Tough	Natural	67	21
Average	128	6	July 7, 1937	15.3	60.8		.2	do	do	64	21
Do	128	12	July 13, 1937	15.4	59.6		.5	2, Tough	do	31	24
Final	128	17	July 19, 1937	14.8	59.4		4.2	Sample, Tough	Musty	26	26
BIN H-8-W (NATURAL VENTILATION, VERTICAL FLUES, WIND ASSISTED) STORED IN 1937											
Initial	500	1	June 30, 1937	15.5	61.3	0.2	([10])	1, Tough	Natural	69	20
Final	500	55	Aug. 24, 1937	14.1	59.5		5.0	Sample, Tough, Weevily	Musty	30	30

BIN H-6-W (ONE CENTRAL VERTICAL FLUE, 20 INCHES IN DIAMETER, WITH SUCTION COWL AND SMALL FAN) STORED IN 1937

Initial	500	1	June 30, 1937	15.3	61.0	0.1	(10)	1, Tough	Natural	67	20
Average	500	70	Sept. 7, 1937	13.5	59.5		5.0	3	do [11]	30	33
Final (inferior) [12]		81	Sept. 11, 1937	14.7	59.2		5.4	Sample	Musty	2	49
Final Remainder [4]		81	do	12.8	59.3	.2	4.2	3	Natural	48	27

BIN H-7-E (FORCE VENTILATED, CENTRAL HALF HEXAGON AIR CHAMBER) STORED IN 1937

Initial	500	1	June 30, 1937	15.4	61.4	0.1	(10)	1, Tough	Natural	71	20
Average	500	7	July 6, 1937	11.0	60.7		0.1	1	do	68	22
Final	500	59	Aug. 27, 1937	10.5	61.4	.2	1.5	1	do	72	21

BIN H-7-W (FORCE VENTILATED, HORIZONTAL FLUES) STORED IN 1937

Initial	500	1	June 30, 1937	15.2	61.4	0.1	(10)	1, Tough	Natural	72	19
Average	500	7	July 6, 1937	11.0	61.2		0.5	1	do	70	20
Final	500	59	Aug. 27, 1937	9.7	61.8	.2	1.0	1	do	72	21

BIN H-5 (BOTTOM VENTILATION, 8-FOOT WHEAT DEPTH) STORED IN 1938

Initial	992	1	July 5, 1938	13.0	56.8	1.0	0	3	Natural	87	11
Average	992	28	Aug. 1, 1938	12.8	56.7	.5	0	3	do	86	18
Do	992	187	Jan. 7, 1939	12.3	56.8	.4	0	3	do		
Do	987	393	Aug. 1, 1939	12.1	57.0	.3		3	do	89	18
Inferior [13]	5	441	Sept. 18, 1939		51.6		80.0	Sample	Musty	22	31
Average	987	574	Jan. 29, 1940	12.1	57.0	.4	0	3	Natural	94	19
Do	987	764	Aug. 7, 1940	12.0	56.7	.5	0	3	do		
Latest	987	909	Dec. 30, 1940	11.6		.4	(10)	3	Natural		

BIN H-10 (BOTTOM VENTILATION, SUCTION COWL, 3 FEET 8 INCHES WHEAT DEPTH) STORED IN 1938

Initial	62	1	July 5, 1938	14.4	57.5	0.5	0	3 Tough	Natural	85	11
Average	62	28	Aug. 1, 1938	13.3	57.7	.5	0	3	do	90	19
Do	62	187	Jan. 7, 1939	12.4	57.7	.5	0	3	do		
Do	62	393	Aug. 1, 1939	11.5	57.5	.7	0	3	do	90	18
Do	62	575	Jan. 30, 1940	11.0	57.0	.8	0	3	do	91	21
Do	62	667	May 2, 1940	11.9	57.1	.9	0	3	do	88	20
Latest	62	938	Jan. 28, 1941	11.8	57.2	.7	0	3	do		

See footnotes at end of table.

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TABLE 11.—*Grade data, days in storage, and quantity of wheat stored in ventilated bins at Hays, in 1936, 1937, 1938, and 1939*—Con.

Sample type	Quantity of wheat	Time in storage	Date	Wheat moisture content	Test weight per bushel	Dockage	Damage	Grade [1]	Odor	Germination	Fat acidity
	Bushels	*Days*		*Percent*	*Pounds*	*Percent*	*Percent*			*Percent*	*Units*
BIN H-11 (BOTTOM VENTILATION, SUCTION COWL, 5 FEET 8 INCHES WHEAT DEPTH) STORED IN 1938											
Initial	94	1	July 5, 1938	14.7	57.5	0.7	0	3 Tough	Natural	90	11
Average	94	28	Aug. 1, 1938	13.0	57.7	.5	0	3	do	86	19
Do	94	187	Jan. 7, 1939	12.7	57.2	.7	0	3	do		
Final	94	213	Feb. 2, 1939	12.7	57.2	.8	0	3	do	87	19
BIN H-12 (BOTTOM VENTILATION, SUCTION COWL, 7-FOOT WHEAT DEPTH) STORED IN 1938											
Initial	125	1	July 5, 1938	14.5	57.5	0.6	0	3 Tough	Natural	87	13
Average	125	28	Aug. 1, 1938	12.7	57.7	.5	0	3	do	86	18
Do	125	187	Jan. 7, 1939	12.9	57.8	.5	0	3	do		
Do	125	393	Aug. 1, 1939	12.0	57.5	.5	(10)	3	do	90	19
Do	125	575	Jan. 30, 1940	11.9	57.0	.6	0	3	do	92	20
Do	125	667	May 2, 1940	12.1	57.0	.7	0	3	do	87	16
Latest	125	938	Jan. 28, 1941	12.0	57.2	.4	0	3	do		
BIN H-6 (FORCE VENTILATED, CENTRAL VERTICAL FLUE) STORED IN 1938											
Initial	825	1	June 30, 1938	16.2	54.1	0.8	0	Sample	Natural	84	11
Average	825	32	Aug. 1, 1938	12.4	56.0	.9	0	3	do	84	16
Do	825	191	Jan. 7, 1939	10.6	55.6	1.3		4	do		
Do	825	397	Aug. 1, 1939	10.1	56.0	1.2		3	do	90	18
Do	825	578	Jan. 29, 1940	11.6	55.7	.6	0	4	do	87	19
Do	825	738	July 8, 1940	11.6	55.8	1.0	(10)	4	do	88	21
WHEAT MOVED FOR MIXING ON JULY 8, 1940, AND RETURNED TO SAME BIN											
Average	[14] 765	767	Aug. 6, 1940	11.9		0.7	(10)	4	Natural		
Latest	765	903	Dec. 30, 1940	11.7	56.0	.8	1.0	3	do		

BIN H-7 (FORCE VENTILATED, AIR CHAMBER ON FLOOR) STORED IN 1938

Initial	934	1	July 1, 1938	13.8	57.0	0.4	0	3	Natural	83	12
Average	934	32	Aug. 1, 1938	10.7	56.7	.4	0	3	do	84	15
Final	934	135	Nov. 12, 1938		56.9	.6	.6	3	do	88	16

BIN H-44 (BOTTOM VENTILATION, SUCTION COWL, SUPPLEMENTARY FORCED VENTILATION) STORED IN 1939

Initial	1,000	2	June 30, 1939	15.7	58.7	0.2	0	Sample	Natural		
Average	1,000	34	Aug. 1, 1939	10.1	59.4	.2	(10)	2	do	71	20
Do	1,000	215	Jan. 29, 1940	10.6	59.5	.1	1.5	2	do	79	22
Do	1,000	308	May 2, 1940	11.4	59.4	.2	1.5	2	do	70	22
Latest	1,000	550	Dec. 30, 1940	11.4	59.1	.3	2.0	2	do		

[1] All wheat of class Hard Red Winter and subclass Dark Hard Winter.
[2] Fat acidity calculated from acid value determination and average oil content of hard red winter wheat.
[3] First sample showing sour odor, from area of about 25 to 30 bushels in center of bin having temperature of 122° F.
[4] Remainder of bin (excluding inferior portion).
[5] Sample of inferior portion (about 100 to 125 bushels in center of bin) taken at time bin was emptied.
[6] Sample from 10 to 15 bushels "heating" portion (temperature 102° F.) near central ventilator flue, about halfway up.
[7] Sample from 20 to 30 bushels in same location.
[8] Sample from 75 to 100 bushels in same location but spreading toward walls. Bin temperature down to 90° F. in warmest spot.
[9] First sample having sour odor.
[10] Trace.
[11] The sampler stated that this sample had a slightly musty odor, but this was not confirmed by the Federal grain supervisor.
[12] Spoiled wheat about 1 inch deep in bottom of bin.
[13] About 5 bushels of wheat directly under filling door. This wheat not included in later average samples.
[14] 60 bushels of spoiled wheat removed before wheat was returned to bin.

The highest temperature in the bin, at the center 1 foot below the upper wheat surface, was lowered from 115° F. at the time of filling to 77° in only 6 days. Despite the low temperatures and comparatively low average moisture content, the wheat developed a sour odor after 95 days in storage.

The fact that the grain used varied so greatly in moisture content and that the air temperatures were higher than the average for Hays, made the conditions under which a ventilated bin had to operate in the 1936 experiments very unfavorable. However, it should be remembered that the same conditions might occur whenever the combine is used and the grain is stored without mixing.

1937 TESTS

The same groups of bins were used in the 1937 studies, but more emphasis was placed on power ventilation and wind-assisted natural ventilation than in 1936. Several of the bins were divided by partitions through the center on the north and south axis so that two different types of ventilating systems could be used in the same bin (fig. 18).

Three new bins, H–10, H–11, and H–12, were built each with a floor area 4 by 5 feet and with double wooden walls, lined on the inside with aluminum foil to retard vapor movement and cooling, and more nearly simulate a full-size bin. Each had a floor of perforated metal, similar to that of bin H–5 in 1936. The three bins were all built together in a line, H–10 and H–12 being on the ends. No ventilating cowls were used. This set of bins was used to test the efficiency of a perforated floor in keeping wheat at various depths, and for comparison with the performance of bin H–5 the previous year.

Bin H–8–W, the west half of a round, 14-foot-diameter, tight-wall and tight-floor metal bin, was fitted with flues and a suction cowl in an effort to take advantage of the comparatively high wind movement in the locality. Four 3-inch-diameter perforated metal flues were set vertically on a line parallel to the partition and 3 feet from it. The flues were spaced 2 feet 4 inches apart in the line. The upper ends of these 4 flues opened to the outside air through a common duct or manifold. Five similar flues were placed 2 feet 6 inches apart in a line only 1 foot from the partition and 2 feet east of the first row, and similarly, 3 other flues (2 feet 6 inches between centers) were placed in a line parallel to the first row and 2 feet 2 inches west of it. The upper ends of the latter 8 flues were connected to a common suction-type cowl by means of a manifold. Thus, 12 vertical flues were arranged so that air, passing into the center row of flues, would pass horizontally through about 2 feet 6 inches of wheat, to the flues connected to the suction cowl. (Fig. 18.)

The 1936 bin H–6, with tight floor, perforated walls, and perforated central flue, was divided in the center by a north and south partition, into two half-round 500-bushel bins. The partition passed through the center of the vertical flue. The west half of this structure, H–6–W, was used for the 1937 studies. A 16-inch propeller-type fan, operated by a 1/12-horsepower motor, was placed just below the suction cowl, with its axis vertical, to assist the wind in drawing air through the wheat.

For tests of power-ventilation systems, a perforated-wall, tight-bottom metal bin, 14 feet in diameter, was divided by a partition to form two half-round bins of the same size (fig.18). Bin H–7–E, the east half, was fitted with a perforated floor and an air-pressure chamber in the center of the bin, made with wood framework covered with perforated metal. The chamber was 1 foot high or thick, and in plan was a half hexagon 3 feet 6 inches in the short dimension. The air path through the wheat was about 3 feet 6 inches to the side, top, or bottom of the stored grain. The air chamber was connected through a 10-inch pipe to a blower for forced ventilation.

The walls of the west half of the bin (H–7–W) were lined with heavy building paper to close the perforations. Three layers of flues each made of two 1- by 4-inch boards, set on edge about 4 inches apart, and covered top and bottom with perforated metal, were placed in this bin, the bottom layer 9 inches, the center layer 4 feet, and the top layer 6½ feet above the floor. The distance between centers of flues in each layer was 2 feet. The bottom and top flues were connected through a manifold to a blower for forced ventilation. The center layer passed through the wall to provide an outlet for air forced into the bottom and top layers. Air could also escape through the upper wheat surface. Unventilated bin H–1–E was used as a check on the performance of the ventilated bins.

Wheat from nearby farms was not used in 1937, but grain was shipped by rail from Enid, Okla., arriving in Hays June 29. This method of handling resulted in the wheat being well mixed and of a much more even and somewhat higher moisture content than in 1936. The initial temperature when stored was also lower. The condition of the wheat at various times during the storage period is given in table 11.

As was expected, the wheat near the center of the unventilated check bin, H–1–E, increased in temperature from 85° F. when filled to 117° on July 15. The first musty odor was noticed in this bin July 13, after 14 days in storage. When moved on July 16 much of the wheat was caked throughout the bin.

The temperature of the wheat in the centers of the series of naturally ventilated bins H–10, H–11, and H–12, at the time of filling, was 87° F. Temperatures rose in H–10 to 109° in 16 days, in H–11 to 121° in 20 days, and in H–12 to 119° in 19 days, after which each bin was emptied because the wheat had developed a musty odor. It was so badly caked that some parts had to be broken up with a shovel before it could be removed.

The temperature of the wheat in bin H–8–W, having the wind-assisted ventilating system utilizing vertical flues, increased very slowly at the center from 84° to 94° F. on August 9, and then cooled slowly to 85° after being in storage 56 days. The first abnormal odor was also noticed at this time. The bin was not emptied until September 11 when some badly spoiled wheat, having a moisture content of 17.1 percent, was found around the bottoms of the intake flues. There was also a small amount of caked wheat on the walls of the bin.

Bin H–6–W, with perforated walls and 20-inch diameter central ventilating flue connected to fan-assisted suction cowl, was somewhat more successful in keeping the stored grain than was bin H–8–W. The fan was operated continuously, except for a period of a few days

when the fan motor was being overhauled. A point in the center of the mass of wheat, initially having a temperature of 85° F., dropped within a few days to 78°. However, a point a few inches from the central flue reached a temperature of 101° on August 6. The average moisture content was reduced from 15.3 percent to 13.5, a loss of 1.8 percent, before the wheat developed a musty odor, compared to a reduction from 15.5 to 14.1, a 1.4-percent loss, in bin H–8–W for the period prior to going out of condition. When the bin was emptied on September 11, 2½ months after filling, a layer of rotten wheat about 1 inch deep was found over the entire floor of the bin, and the wheat was also caked slightly in the center of the bin.

The ventilating systems of both power-ventilated bins, H–7–W and H–7–E, were supplied with air at the same time from the same blower at the rate of 540 cubic feet per minute to each bin. The blower was operated continuously from 9 a. m. June 30 until 7 p. m. July 7, and then intermittently until July 11, for a total of 159 hours. In H–7–E the wheat moisture content was reduced from 15.4 percent to 11.0, a drop of 4.4 percent. The wheat in bin H–7–W was reduced from 15.2 percent to 11.0, a drop of 4.2 percent, in the same 159-hour period. When the two bins were emptied on August 25 and 27, the wheat was dry and hard, and in excellent condition. The temperatures of the wheat near the center of each bin, about 84° F. when filled, dropped after 22 hours of ventilation to 61°.

1938 TESTS

To provide better drainage and to give the ventilated bins more exposure to the wind, the experimental bins were moved to the top of a hill southeast of the Fort Hays Experiment Station buildings, for the 1938 studies.

It was decided to repeat in 1938 the 1936 test of screen-bottom ventilation, using the original bin H–5, which had tight metal walls and a galvanized screen bottom, but to attempt to get well-mixed wheat of approximately the same average moisture content as placed in this bin in 1936. To further test and if possible increase the efficiency of this type of ventilation, bins H–10, H–11, and H–12, were equipped with suction type ventilating cowls on the roofs to assist the flow of air up through the wheat. The ventilating spaces around the eaves were closed.

The quick drying in the forced-ventilation bins of 1937 suggested further work along this line, with special attention to simplifying the systems and utilizing blowers to be found in the ordinary mechanized farm, such as blower elevators and silo fillers.

The partition was removed from 1937 bin H–6–W, leaving it as it was in 1936, with a 20-inch-diameter perforated flue set vertically in the center of a 14-foot-diameter perforated-wall metal bin. The perforations in the flue were increased in diameter so that they totaled about 4 percent of the flue surface. The upper end of the flue was blocked about 18 inches below the upper wheat surface and the bottom connected through a 6-inch-diameter pipe to a grain blower driven by a 3-horsepower motor. This motor was larger than necessary but was the only one available. Air forced into the central flue had to pass into the wheat and through the perforated bin walls and upper wheat surface.

Another perforated-wall, tight-bottom, 1,000-bushel metal bin, H–7, was prepared for forced ventilation by building in the center of the floor a square air chamber, 4 feet on the side and 2 feet high, of perforated metal supported on a wooden frame. The chamber was connected through a duct to a heavy-duty fan belted to a 1-horsepower electric motor. The passage of air was from the fan to the air chamber, and through the wheat to the perforated walls and upper wheat surface.

The wheat stored in the ventilated bins in 1938 was purchased from a local elevator. All bins were filled between June 30 and July 5, and the first samples were drawn a few days later. The bushels stored, days in storage, grade, germination, and fat acidity determinations for the initial and successive samples from all the experimental bins are given in table 11.

The wheat in bin H–5 cooled from an initial center temperature of 86° to 80° F. in 1 week; and at no time thereafter did any point in the wheat, except near the metal walls, exceed this temperature. Drying was very slow, as shown in table 11, averaging about 0.25 percent per month during July and August, but the wheat remained in good condition. At the latest sampling, on December 30, 1940, after 909 days in storage, no abnormal odor was evident and there was little deterioration of wheat quality. In August of 1939 about 5 bushels of wheat directly under the filling door was observed to be musty but as this wheat was excluded from the average sample the abnormal odor did not appear in it.

The series of bins, H–10, H–11, and H–12, were filled with wheat of somewhat higher moisture content, averaging about 14.5 percent. The initial center temperature of 83° F. in H–10 dropped to 80° in 2 weeks and never exceeded this level. H–12 took 3 weeks to cool off from 83° to 80°, and H–11 4 weeks to lower from 84° to 80°. None of these bins showed any indications of heating during the storage period. During the first month of storage H–10 lowered in average moisture content 1.1 percent; H–11, 1.7 percent; and H–12, 1.8 percent; the most drying taking place in the bin with the greatest depth of wheat.

Bin H–11 was emptied on February 2, 1939, after 213 days of storage. The wheat at that time was in very good condition. Bins H–10 and H–12 were still in storage on January 28, 1941 (938 days after filling) and the wheat, as shown in table 11, showed little deterioration from the original condition.

Bin H–6, with central perforated flue receiving air from the grain blower, was filled with 825 bushels of well-mixed wheat, averaging 16.2 percent moisture content, on June 30, 1938. The blower was started at once and ran continuously for 31 days until, on August 1, the average moisture content had dropped to 12.4 percent. Samples taken at 5–day intervals showed that during the first 5 days the moisture content near the flue was reduced to 9.2 percent while the moisture in the wheat at the wall and halfway between the central flue and wall was reduced only a fraction of a percent. At the end of 2 weeks, the moisture content at a point equidistant from bin walls and central flue had lowered to 10.3 percent while the wall areas did not dry out until after the blower was stopped.

Temperature within the bin dropped in the areas where drying was progressing at the most rapid rate. The temperature near the

flue dropped as low as 61° F. during the first 5 days of blower operation but after the moisture content was lowered to 9.2 percent, the temperature in this region followed the air temperature. The wheat at a greater distance from the flue then cooled until it, too, had been dried after which its temperature followed the air temperature.

After the first month of storage, the average wheat moisture content stayed at 12 percent or lower, as shown by the data in table 11. However, in July 1940, after 2 years' storage, it was found that the wheat on about one-third of the bin circumference, on the northwest side of the bin, extending approximately 1 foot in and half way up the wall, was musty and caked and the wheat on the floor directly below the spoiled portion was very wet and rotten. The entire lot of out-of-condition grain, amounting to 60 bushels, was removed, the bin thoroughly cleaned, and the remaining unspoiled wheat, approximately 765 bushels, returned to the bin H–6 for further observation. At the latest sampling, on December 30, 1940, 903 days after the original filling date, the wheat was apparently still in good condition.

When the spoiled wheat was found in bin H–6, from the location of the caked areas and consideration of the previous weather it was concluded that rain, driven by a high wind, had entered the bin through the wall perforations.

Uniformly high-moisture-content wheat could not be obtained for bin H–7, but rather than discontinue the test, wheat with an average initial moisture content of 13.8 percent was used. This wheat varied greatly in moisture content, ranging from 12 percent to 17. The blower was started immediately after filling and ran continuously for 30 days. As was the case with bin H–6, drying took place at the most rapid rate near the fresh-air inlet, and during this period the wheat temperature was lowered. The last wheat to be dried was near the walls and upper wheat surface.

Samples indicated that after the first 10 days of blower operation no moisture was removed. On July 11 the average moisture content was 10.4 percent, 0.3 percent lower than it was when the blower was stopped 20 days later. During this 10-day period, the average outside air temperature was 85° F. and the average relative humidity 36.5 percent. The wheat was disposed of November 12, at which time it was in excellent condition. (See table 11.)

1939 TESTS

A new commercial bin, incorporating the ventilation features tested in bins H–10, H–11, and H–12 in 1938, was secured for the 1939 tests. This was H–44, a round metal bin with tight walls and a perforated metal floor. A suction cowl similar to those used on the bins just mentioned was attached at the peak of the conical roof. All openings and cracks in the roof and at the eaves were calked so that the negative pressure developed by the cowl would be utilized in pulling air up through the wheat by way of the perforated floor. The bin was 14 feet in diameter and 8 feet high to the eaves.

On June 29, 1939, 1,000 bushels of well-mixed wheat with an average moisture content of 15.7 percent was placed in the bin. The highest moisture content observed was 16.1 percent. The wheat temperature averaged 80° F. when stored. This increased in the upper part of the bin to about 95° by July 5. As a slightly musty

odor was developing and it was believed the wheat was going out of condition a blower, operated by a 1-horsepower electric motor, was attached to the pressure cowl opening on the bin roof in such a manner that air was forced down through the 8 feet of wheat and out via the perforated floor. The wheat temperature in the upper part of the bin lowered to below 80° after a few hours of forced ventilation. The top layers of wheat also dried rapidly to 10 percent while the bottom was the last to dry. The blower was stopped on July 18, 1940, at which time the average wheat moisture was 10.1 percent. During the power ventilation period several observations indicated wheat temperatures well over 100° in the upper part of the bin, after the wheat had lost most of its moisture, due to the high outside air temperatures. After July 18 the blower was removed and the suction cowl again placed in operation. At the latest sampling, on December 30, 1940, the wheat was still in very good condition, as shown by the grade data in table 11.

Results of Kansas Ventilation Tests

In studying table 11, where moisture and grade data from successive average samples of the wheat stored in each of the experimental ventilated bins are given, it is found that in all except the 1936 tests, the wheat that was not reduced in moisture content to about 12 percent in a month or two went out of condition quickly. No bin using natural ventilation, or not using some sort of power ventilation, successfully stored wheat with a moisture content over 15 percent for more than 80 days. This was in contrast to the North Dakota results and the difference can probably be attributed to the lower air temperatures in that area immediately after harvest. At Hays, bottom ventilation with a suction cowl safely stored wheat with an average moisture content of about 13.0 percent when the moisture distribution was uniform, as in H–5 (1938), and when it was very uneven (H–5, 1936). This type of ventilation was unsuccessful with wheat over 15 percent (H–10, H–11, and H–12, 1937). By adding a suction cowl to the roof above the grain in the perforated floor bins, wheat with a moisture content of 14.5 percent was successfully stored (H–10, H–11, and H–12, 1938) but that of 15.7 percent moisture was not (H–44, 1939). Excluding 1936 bin H–8, the power-ventilated bins safely stored wheat with average moisture contents ranging from 13.8 percent to 16.2.

In power-ventilated bins, after the wheat is dried down to about 12 percent and the blowers are stopped, storage conditions are much the same as in unventilated bins because little air circulation is then maintained. It is doubtful whether the same thing can be said of the conditions in a naturally ventilated bin because even if no drying takes place after the initial storage period, some advantages or disadvantages may result from the cooling or heating. However, in table 12 an attempt has been made to summarize the length of storage period observed for each wheat moisture content in all of the large bins except the ventilated bins in which the wheat went out of condition in the first month. The length of storage period given for the unventilated bins is from the original filling date and the moisture content given is that of the wheat when placed in storage. For the ventilated bins the wheat moisture content used is the average of the successive moistures given in table 11 for each bin, excluding the first

sample; the length of storage is the total storage period excluding the period between the first and second samplings, usually amounting to about 1 month. In table 12 the ventilating systems are not compared but only the length of storage observed for each wheat moisture content. It is assumed that after the wheat is dried conditions in a ventilated bin are about the same as in an unventilated bin.

TABLE 12.—*Odor in wheat in large bins at Hays after storage for different lengths of time and different percentages of moisture content*

Wheat moisture content [1] (percent)	Time in storage	Wheat odor at end of observation period	Bins included and year
	Days		
15.3	16	Sour	H-1-E, H-2-E, H-4-E (1937).
14.8	41	do	H-4-W (1937).
14.4	41	do	H-2-W, H-3-W (1937).
Over 14.0	20-30	do	3 Kansas survey bins (1939).
13.4	68	Natural	H-1-W (1937).
Over 13.0	90	Sour	5 Kansas survey bins (1939).
12.8 [2]	185	Natural	H-11 (1938).
12.3 [2]	910	do	H-12 (1938).
12.2 [2]	881	do	H-5 (1938).
12.2-12.8 [3]	11	Sour	H-1, -2, -3, -4, -7 (1936).
12.0 [2]	910	Natural	H-10 (1938).
11.4 [2]	871	do	H-6 (1938)—moved once.
11.3	923	do	H-8 (1938. Wheat moved from H-5, 1936).
10.9 [2]	516	do	H-44 (1939).
10.7	103	do	H-7 (1938).
10.2 [4]	482	do	H-2 (1938).

[1] Initial moisture content for unventilated bins and average moisture content, excluding first month, for entire storage period of ventilate bins.
[2] Naturally ventilated bins.
[3] Observed moisture content range in bins from 10 to 18 percent.
[4] Observed moisture content range in bins from 8.5 to 15 percent.

This summary shows that, except in the 1936 tests, whenever the moisture content was under 13 percent none of the wheat developed an abnormal odor. The time the wheat was under observation in these tests ranged from 103 days to 923.

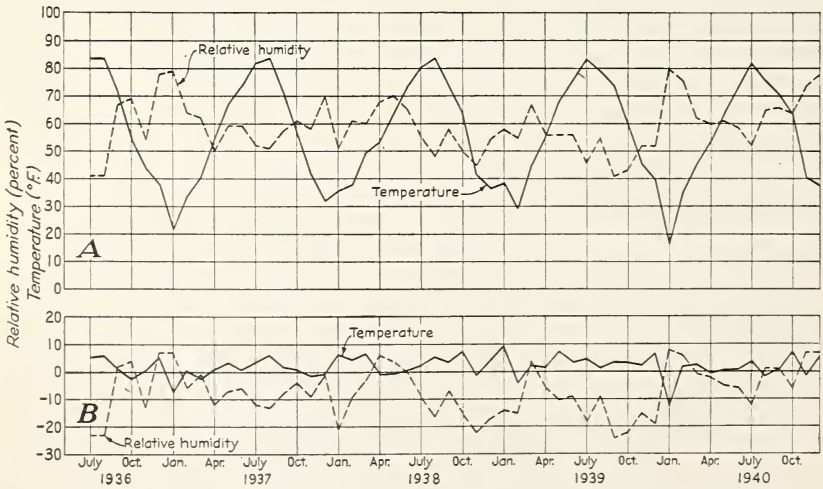

FIGURE 19.—Average monthly air temperature and relative humidity (*A*) and departures of air temperature and relative humidity from the normal (*B*), at Dodge City, Kans., for the period July 1936 to December 1940.

The weather during the period covered by the tests was unusually favorable for drying, as shown by the graphs of the average monthly air temperatures and relative humidities, and their departures from the normal, in figure 16. These data are from the Weather Bureau records at Dodge City, Kans., the closest station to Hays. As at Fargo, N. Dak., the air temperatures have been somewhat higher and the relative humidity somewhat lower than normal during the summer and fall months of the test period. This fact should be taken into consideration when comparing the results of the different ventilation systems and in estimating moisture limits for safe storage.

WHEAT STORAGE IN MARYLAND

Soft red winter wheat is grown generally from the Mississippi River eastward to the Atlantic coast. Storage problems for this area may be roughly divided, on the basis of handling practices, into those of

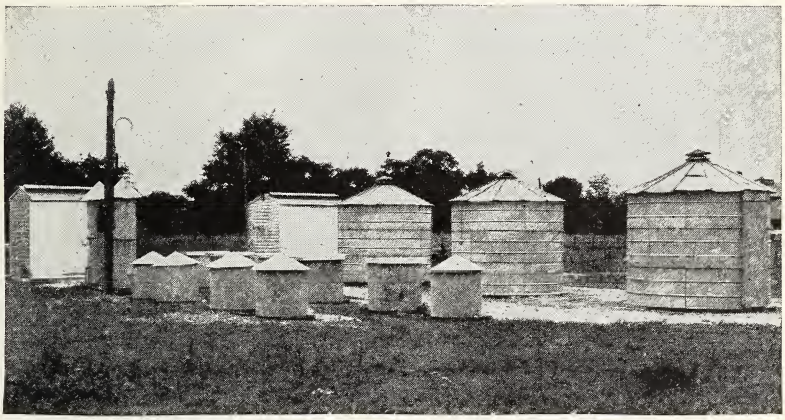

FIGURE 20.—Experimental bins at College Park.

the inland States west of the Appalachian Mountains including Illinois, Michigan, Indiana, Ohio, and Iowa, and those of the mountain and coast states, New York, Pennsylvania, Maryland, and Virginia. Maryland, with wheat-growing sections both in the mountains and on the Coastal Plain, was considered to be representative of the eastern area, and Illinois of the inland States.

Because the facilities of the Maryland Agricultural Experiment Station were available at College Park with temperature, humidity, and wind-velocity conditions about as adverse to successful storage as at any location in the State, the experimental bins were placed there (fig. 20). The site was on low ground surrounded by trees or buildings to within 200 feet, which tended to shut off any wind and also probably increased the average temperatures and humidity.

EXPERIMENTS WITH UNVENTILATED FARM-SIZE BINS

1936 EXPERIMENTS

Six 250-bushel experimental bins were filled at College Park in 1936. Each bin was the east or west half of a 500-bushel bin divided in the center by a north-south wooden partition. Thus, bin B–1 was the

east half of a round metal bin 10 feet in diameter and 8 feet high to the plate, with a wooden floor, and bin B–2 was the west half of the same bin, identical except for the floor which was concrete, 6 inches thick, over a 6-inch gravel fill. The floor surfaces in all bins were at the same level.

Bins B–3 and B–4 were the east and west halves, respectively, of another 500-bushel round metal bin. Both sides had wood floors and were lined with ½-inch insulation board supported three-fourths of an inch away from the metal wall by furring strips. Insulation board was bolted directly to the conical metal roof, without the use of furring strips. Bin B–3, the east half, was provided with four vertical tubes of various shapes, made of insulation board and set on the bin floors to allow the escape of heat from the wheat mass, and also absorb moisture from the grain.

Two 500-bushel wood granaries, one having single thickness wall and the other a double thickness wall with building paper between, were also divided by partitions into 250-bushel bins, each 5 by 10 feet in floor area. Bins B–5 and B–6 were the east and west halves of the single thickness wall building, and B–7 and B–8 the east and west halves of the double thickness wall building. Air circulation across the top of the wheat in each bin was provided by leaving off the top 6-inch board on the east and west sides and covering the opening with hardware cloth to keep out birds. As bins B–6 and B–8 were ventilated with horizontal flues, they are discussed on page 69.

The bins were filled on July 11, 1936, with well-mixed soft red winter wheat with a uniform moisture content of approximately 16.4 percent, and an average temperature of about 86° F. The wheat temperature increased in the center of each bin to 120° in 1 month. The wheat at this time was sour and badly caked and the bins were emptied. The average test weight for the six bins had dropped 2.9 pounds and the germination had decreased from an average 88 percent to 24 percent. Bread made from samples obtained when the bins were emptied had a musty odor, and the loaf volume, crumb and crust color, and grain and texture were also inferior. There was no difference in the changes in wheat temperature, quality or percent germination in the various bins that could be attributed to the different materials of construction.

The initial and final grades, grade factors, germination percentages, and other data are given for each bin in table 39 of the appendix.

1937 EXPERIMENTS

The 1936 investigations, just described, indicated definitely that wheat with a moisture content above 16 percent, even if well mixed, could not be safely stored at College Park. In the farm survey of wheat storage conducted in Maryland in 1936 (p. 95, Surveys of Bins on Farms) it was observed that almost all of the bins were in barns protected from the direct rays of the sun. For this reason in the 1937 experiments several of the bins were shaded to simulate actual farm conditions in the area as closely as possible. The insulation-board lining was removed from the walls of 1936 bins B–3 and B–4, and the entire roof removed. Another circular metal shell, 10 feet in diameter and 8 feet high, divided by a north-south partition into two bins, B–25 on the east and B–26 on the west, was set up about 10 feet

west of B–3 and B–4, on a wooden floor. A canopy or sun shade of corrugated iron was then built over both B–3 and B–4, and B–25 and B–26, shading the entire bins during the hottest part of the day, but because it was several feet above the bin walls, allowing free flow of air across the top of the wheat. No conventional bin roofs were used. The canopy extended 6 feet over the south sides of the bins and 3 feet over the north sides.

The east half of the single wall 1936 wood bin, B–5, was also shaded, but instead of a canopy, ¼-inch plywood was supported about 4 inches away from all walls on vertical nailing strips. Air could move freely in a vertical direction between the bin wall and this shade. The wooden roof was protected from solar heat by a layer of paper-backed aluminum foil on the underside of the roof boards.

Bin B–1, the east half of a 500-bushel round metal bin, with wood floor, was left the same as in 1936, as a check on the performance of the shaded bins. The walls and roof of the west half of the same circular bin, B–2, were insulated with ½-inch insulation board, furred three-fourths of an inch away from the walls but bolted directly to the roof without furring strips. The floor, of concrete, was left the same as in 1936.

Soft red winter wheat, well mixed and very uniform in moisture content, was used in 1937. The average moisture content of the wheat in each bin is given in table 13, along with the quantity of grain, grade factors, percent germination and fat acidity obtained from initial and later samples. The highest moisture-content wheat, 15.4 percent in bin B–25, was 1 percent below the moisture content of the wheat used in 1936. The initial wheat temperature was also somewhat lower, averaging 78° F. as compared with 85° in 1936.

The wheat in none of these bins showed any indication of heating during the early storage period. However, the wheat in the shaded bins B–3, B–4, B–5, B–25, and B–26, cooled off faster than in the plain metal bin B–1 or the insulated bin B–2, and averaged several degrees lower during July, August, and September than in the plain metal bin. (*4*)

Water leaked past the filling doors of bins B–1 (plain metal) and B–2 (shaded metal) during heavy rains in the latter part of August 1937, and the wheat in B–2 developed a musty odor by September 3, and B–1 by December 18, as shown in table 13. The wheat in all of the shaded bins turned sour between March 12 and April 23, 1938, when the outside air temperature began to rise. There was little difference in the rate of deterioration of the wheat stored in the shaded bins at different initial moisture contents, except for a slightly smaller decrease in percent germination in the 14.2-percent-moisture wheat in bin B–3 than in the other shaded bins (table 13).

An experiment was made in the fall of 1937 to determine the effect of color and shading on bin-wall temperatures, and to check the results from such experiments against temperatures actually observed in large bins. Five 3-inch-diameter cylinders 12 inches long were constructed of galvanized metal. One was painted black, one left plain, without painting, and the remaining three jacketed with galvanized metal jackets spaced ½, 1, and 1½ inches away from the inner cylinder, respectively. The 5 cylinders were set side by side in a vertical position in the sun, about 10 feet above the ground. Air could pass freely between the jackets and inner cylinders but the

TABLE 13.—*Grade factor data, percent germination, and fat acidity of wheat stored in unventilated bins at College Park, in 1937 and 1938*

Sample type	Quantity stored	Days in storage	Date sampled	Wheat moisture content	Test weight per bushel	Dockage	Damage	Grade [1]	Odor	Germination	Fat acidity
	Bushels			*Pct.*	*Lbs.*	*Pct.*	*Pct.*			*Pct.*	*Units*
BIN B-1 (EAST HALF OF PLAIN METAL BIN), 1937											
Average	190	0	July 23, 1937	14.6	56.7	0.2	2.9	3, Tough, Garlicky	Natural	90	20
Do	190	42	Sept. 3, 1937	14.7	56.5	.2	2.9	do	do	81	22
Inferior [2]	20	83	Oct. 4, 1937	16.7	52.5	.3	7.2	Sample, Garlicky	Musty	11	60
Remainder [3]	170	83	do	14.7	56.5	.2	2.9	3, Tough, Garlicky	Natural	49	28
Average	190	158	Dec. 18, 1937	15.0	54.8	.2	3.7	Sample, Tough, Garlicky	Musty	38	26
BIN B-2 (WEST HALF OF METAL BIN INSULATED WITH INSULATION BOARD), 1937											
Average	186	0	July 23, 1937	14.6	56.8	0.2	2.8	3, Tough, Garlicky	Natural	93	17
Do	186	35	Aug. 27, 1937	14.7	56.4	.2	2.8	do	do	80	22
Do	186	42	Sept. 3, 1937	14.8	56.3	.2	3.2	Sample, Tough, Garlicky	Musty	72	23
BIN B-3 (EAST HALF OF METAL BIN UNDER CANOPY SHADE), 1937											
Average	165	0	July 23, 1937	14.2	57.4	0.2	2.9	3, Tough, Garlicky	Natural	91	14
Do	165	42	Sept. 3, 1937	14.2	57.2	.2	2.9	do	do	78	19
Do	165	148	Dec. 18, 1937	14.3	57.0	.2	2.9	do	do	80	19
Do	165	232	Mar. 12, 1938	14.2	57.0	.2	3.0	do	do	74	22
Do	165	274	Apr. 23, 1938	14.4	56.3	.2	3.0	Sample, Tough, Garlicky	Sour	73	[4] 26
BIN B-4 (WEST HALF OF METAL BIN UNDER CANOPY SHADE), 1937											
Average	188	0	July 23, 1937	14.7	56.8	0.2	2.9	3, Tough, Garlicky	Natural	89	17
Do	188	42	Sept. 3, 1937	14.7	56.4	.2	2.9	do	do	86	21
Do	188	148	Dec. 18, 1937	14.7	56.2	.2	3.0	do	do	76	19
Do	188	232	Mar. 12, 1938	14.7	56.0	.2	3.0	do	do	79	21
Do	188	274	Apr. 23, 1938	14.7	56.0	.2	3.0	Sample, Tough, Garlicky	Sour	58	[4] 25
BIN B-26 (WEST HALF OF METAL BIN UNDER CANOPY SHADE), 1937											
Average	180	1	July 21, 1937	15.2	57.8	0.3	1.8	3, Tough, Garlicky	Natural	91	14
Do	180	49	Sept. 7, 1937	15.2	58.0	.3	1.8	2, Tough, Garlicky	do	80	21
Do	180	151	Dec. 18, 1937	15.2	58.0	.3	1.8	do	do	74	21
Do	180	192	Mar. 12, 1938	15.2	58.2	.3	1.9	do	do	76	21
Do	180	276	Apr. 23, 1938	15.3	57.5	.3	2.8	Sample, Tough, Garlicky	Sour	66	[4] 29

BIN B-25 (EAST HALF OF METAL BIN UNDER CANOPY SHADE), 1937

Average	189	0	July 29, 1937	15.4	57.3	0.4	2.2	3, Tough, Garlicky	Natural	85	16
Do	189	35	Sept. 2, 1937	15.4	57.0	.4	2.2	do	do	84	22
Do	189	142	Dec. 18, 1937	15.4	56.8	.4	2.5	do	do	64	23
Do	189	226	Mar. 12, 1938	15.5	56.5	.4	2.6	do	do	60	22
Do	189	268	Apr. 23, 1938	15.5	56.0	.4	3.0	Sample, Tough, Garlicky	Sour	[5] 53	[4] 26

BIN B-5 (EAST HALF OF WOOD BIN SHADED WITH PLYWOOD), 1937

Average	240	1	July 23, 1937	14.6	56.7	0.2	2.9	3, Tough, Garlicky	Natural	90	19
Do	240	42	Sept. 2, 1937	14.7	56.5	.2	2.8	do	do	86	21
Do	240	149	Dec. 18, 1937	14.7	56.2	.2	3.2	do	do	78	21
Do	240	233	Mar. 12, 1938	14.7	56.0	.2	3.2	do	do	75	23
Do	240	275	Apr. 23, 1938	14.7	56.0	.2	3.4	Sample, Tough, Garlicky	Sour	57	[4] 25

BIN B-28 (WHEAT PASSED THROUGH EXPERIMENTAL DRYING MACHINE ONCE), 1938

Average	380	1	July 14, 1938	14.8	58.2	0.4	2.7	Sample, Tough, Garlicky	Fire-burnt	73	18
Do	380	27	Aug. 9, 1938	14.8	57.6	.4	2.9	do	Sour, fire-burnt	20	30

BIN B-29 (WHEAT PASSED THROUGH MACHINE ONCE, AFTER 2 WEEKS' STORAGE IN METAL BIN), 1938

Average	383	1	July 26, 1938	14.4	57.7	0.3	4.7	Sample, Tough, Garlicky	Fire-burnt [6]	32	27
Do	383	60	Sept. 23, 1938	14.2	57.5	.3	4.8	do	do.[6]	8	29

BIN B-27 (WHEAT PASSED THROUGH DRYER TWICE), 1938

Average	390	1	July 14, 1938	13.7	58.0	0.3	3.8	Sample, Garlicky	Fire-burnt [6]	65	15
Do	390	162	Dec. 22, 1938	13.5	58.0	.3	4.0	do	do.[6]	32	23

BIN B-30 (WHEAT NOT DRIED), 1938

Average	396	0	July 11, 1938	13.3	59.1	0.5	0.8	2, Garlicky	Natural	90	14
Do	396	164	Dec. 22, 1938	13.3	59.1	.5	.8	do	do	82	19
Do	396	259	Mar. 27, 1939	13.4	59.0	.5	.9	do	do	66	19
Do	396	612	Mar. 15, 1940	13.5	58.5	.5	1.6	do	do	57	24
Do	396	967	Mar. 5, 1941	13.5	58.3	.5	1.8	do	do	60	33

[1] All wheat of class Soft Red Winter and subclass Red Winter.
[2] Sample of approximately 20 bushels of musty wheat directly under roof filling door.
[3] Remainder of bin, not including any of the interior portion.
[4] Fat acidity of average sample drawn May 16, 1938.
[5] Germination percentage of sample drawn May 16, 1938.
[6] No sour odor could be detected because of the fire-burnt odor but there was a slight musty odor in flour, dough, and bread, and a slight musty taste to the bread made from the wheat.

ends of the inner cylinders were closed to shut off air flow. Temperatures were taken, by means of thermocouples soldered to the inside walls of each cylinder, at 1 p. m. on three bright sunny days, September 21 and 24, and October 12, 1937. At the same time temperatures were taken of the walls of the plain metal bin B–1 and the shaded bin B–4 (under the canopy). As shown in table 14 the effect of the paint and of the shades spaced at various distances from the cylinder walls are apparent, but are much less than the differences noted between the wall temperatures of the shaded and unshaded bins.

TABLE 14.—*Temperatures observed on inner south walls of experimental cylinders and at south walls of bins B–1 and B–4 at College Park in 1937*

Location of thermocouple	Temperature on—			
	Sept. 21	Sept. 24	Oct. 12	Average
	° *F.*	° *F.*	° *F.*	° *F.*
Black cylinder	99	98	98	98
Galvanized cylinder	95	94	96	95
Cylinder with ½-inch jacket	84	85	84	84
Cylinder with 1-inch jacket	81	84	82	82
Cylinder with 1½-inch jacket	79	84	81	81
Bin B–1 (plain metal)	126	130	128	128
Bin B–4 (shaded metal)	67	74	72	71

1938 EXPERIMENTS

The wheat used in the investigations at College Park in 1936 and 1937 was all too high in moisture content for safe storage in unventilated bins for 1-year periods, even at the relatively favorable temperature conditions provided by the shades and canopies. An experimental artificial drying machine was developed in connection with the project, and the purpose of the 1938 storage tests was to determine the suitability of wheat for storage when dried in the machine.

As the 1937 wheat was still under observation for moisture and temperature changes in the 1937 bins, a new 4-bin plywood granary was built[6] (fig. 21). The floor area, 14 by 24 feet, was divided into four bins each 7 by 9 feet, and a 6- by 14-foot work alley. The bin walls and partitions were of ½-inch plywood, 10 feet high to the plates, and the floors were also of plywood, two layers each ½-inch thick under the two east bins, and one layer ½-inch thick under the west bins and alley. The roof was of corrugated sheet steel. The four bins, B–27, B–28, B–29, and B–30 were located in the northeast, southeast, southwest, and northwest quarters of the granary, respectively.

For the drying tests 1,200 bushels of wheat ranging in moisture content from 15.6 to 15.8 percent was obtained and divided into three 400-bushel lots for storing, after drying, in bins B–27, B–28, and B–29. The wheat for bin B–27 was run through the drying machine twice, being heated first to 126° F. and then to 129°. This reduced the moisture content to 13.7 percent but the average wheat temperature after being stored was 97°. The wheat for bin B–28 was run through the dryer once, being heated to 124° in the process, and dried to 14.8 percent moisture. The wheat temperature when stored

[6] Except for sheathing, constructed according to U. S. Department of Agriculture design number 5528

was also about 97°. The wheat for bin B–29 was left in storage in a metal bin for 2 weeks before drying and was then heated to a temperature of 138° in the dryer, the moisture being reduced to 14.4 percent. Because of the type of experimental dryer used, all of the wheat after drying had a fireburnt odor, causing it to grade Sample.

The wheat in bin B–30, from another lot, was not dried but was stored at its natural moisture content, 13.3 percent, and had an average initial temperature of 85° F.

The initial and later grade data, percent germination, fat acidity, and other factors, are given for the wheat in these four bins in table 13.

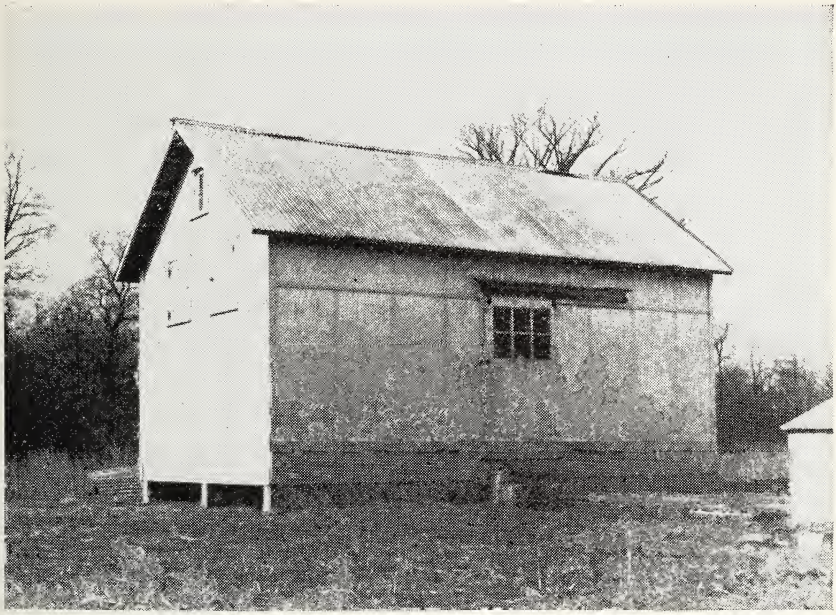

FIGURE 21.—Four-bin plywood granary constructed at College Park in 1938.

The wheat of the highest moisture content, 14.8 percent, in bin B–28 began to increase in temperature immediately after storage, going from the original average temperature of 97° F. to a high of 119° near the bin center on August 6, 1938. A sour odor was evident on August 9, and the deterioration as measured by percent germination and fat acidity also indicated a rapid lowering of quality. Except for the wheat near the south side of B–27, next to the heating wheat in bin B–28, the rest of the 1938 wheat cooled slowly, showing no indication of heating. However, as shown by the footnotes to table 13, bread made from the wheat in bins B–27 and B–29 had a musty taste and odor on December 22 and September 23, respectively, although a sour odor could not be detected in the wheat at those times, probably because of the fire-burnt odor. Samples taken when the bins were first filled made bread with a normal odor.

The wheat in bin B–30, that had been stored at its original moisture content of 13.3 percent remained in storage until March 5, 1941, a

422157°—42——5

period of 967 days, and as shown by the grade data for average samples in table 13, was at that time in good condition. However, samples taken from various parts of the bin at that time indicated that the fat acidity of the wheat at the center of the bin had increased to 49.8 units and the germination lowered to zero.

SUMMARY OF EXPERIMENTS WITH UNVENTILATED FARM-SIZE BINS

Wheat with a moisture content of 16.4 percent heated and quickly went out of condition in the 1936 tests, and there were no differences in the changes in wheat temperature, quality or germination percentage that could be attributed to the different materials of construction.

In the 1937 tests wheat was stored in shaded and unshaded bins, the wheat moisture content among bins ranging from 14.2 to 15.4 percent. While the temperature conditions were more favorable for storage in the shaded than in the unshaded bins, wheat of all moisture contents developed a sour odor in about 9 months. The loss in germination was slightly less in the wheat of 14.2 percent moisture content than at the higher percentages. Faulty roof construction in two of the unshaded metal bins allowed water from rains to enter the bin, causing early spoilage.

Wheat of 13.3 percent moisture content was stored safely in a 400-bushel plywood bin on the north side of a granary for a period of over 900 days, although at the end of that time the wheat at the center of the bin had lost all viability and had a very high fat acidity.

Small-Bin Studies

In 1936, 10 small bins of about 20-bushel capacity were filled with wheat of various moisture contents to observe the effect of bin size, wheat moisture content, and insulation on the rate of deterioration. Five bins, B–9, B–10, B–11, B–12, and B–13 were insulated on the sides and bottom with 3 inches of glass wool and on top with covers of two thicknesses of 1-inch insulation board, while five others, bins B–14, B–15, B–16, B–17, and B–18 were of plain galvanized metal with conical metal tops; all were 40 inches in inside diameter and 36 inches high. These bins were filled in pairs of one plain and one insulated bin: B–13 and B–14 from the same lot of wheat of 16.4 percent moisture content used in filling the large bins that year; B–11 and B–16 with 15.7 percent; B–10 and B–17 with 15 percent; and B–9 and B–18 with wheat of approximately 11.3 percent moisture content. Peat was mixed with the wheat placed in bins B–12 and B–15; therefore they are discussed on page 127.

The initial grade factors, temperature, etc. of the wheat in each bin, and the grade factor data from later samples, are given in table 39 of the appendix. None of the wheat went out of condition or heated during the early storage period. The wheat in bins B–13 and B–14, of 16.4 percent moisture content, was removed June 1, 1937, after about 11 months in storage, and at that time there was no indication of the development of an abnormal odor. It will be remembered that wheat from the same lot stored in 250-bushel bins heated badly and turned musty in one month of storage. No samples for germination and fat acidity were taken from the small bins in 1936 but that there was some deterioration, is indicated by the decrease in test

weight—1.7 pounds in bin B–14 (plain metal) and 1.0 in bin B–13 (insulated). During the same period (11 months) the plain metal bin dropped 2.3 percent in moisture content and the insulated bin 1.4 percent.

The 15.7 percent-moisture wheat in bins B–11 and B–16 was removed January 8, 1937, after 5½ months storage, and was also in good condition, although the test weight had dropped somewhat—0.9 pound in the plain metal bin and 0.2 pound in the insulated bin. The 15.0 percent-moisture wheat in bins B–10 and B–17 was not removed until June 1, 1937 (11 months after being stored), at which time little deterioration was apparent.

The 11.3-percent-moisture-content wheat in bins B–9 and B–18 was not disturbed until the fall of 1939, over 3 years after being stored, although samples were taken at intervals. The wheat in the plain metal bin B–18 had a sour odor on September 13, 1939, and had dropped 2.3 pounds in test weight compared to a 1.6-pound loss in the insulated bin, B–9. The wheat in B–9 had no abnormal odor. When the two bins were emptied on November 30, 1939, a layer of wet and rotten wheat 3 inches thick was found on the bottom of the uninsulated bin while the bottom of the insulated bin was clean, with no evidence of condensation or spoilage of wheat.

In general, the wheat in the small insulated bins remained cooler during the first few months of storage, when accurate records of wheat temperatures were obtained, than did the wheat in the uninsulated bins, and also decreased less in test weight during the respective storage periods.

Six small 20-bushel unventilated bins were filled with untreated wheat of the 1937 crop. Three, bins B–15, B–16, and B–17, were of plain metal, with conical roofs; two, bins B–10 and B–11, were insulated with 3 inches of rock wool, and one, bin B–13, was shaded by wrapping aluminum foil paper, shiny side out, around a plain metal bin, over vertical furring strips 1¾ inches thick. Air could pass freely up between the metal bin wall and the aluminum foil paper. The bin was covered with a flat roof of two thicknesses of insulation board separated by 3 inches of rock wool. The top insulation board was painted with aluminum paint to reflect as much of the sun's heat as possible.

One of the small plain metal bins and one of the insulated or shaded bins were filled with wheat of each of the three moisture contents that were stored in the large bins—15.5, 14.6, and 14.2 percent, respectively. A comparison is made in table 15 of the quality and temperature changes observed in the wheat stored at the various moisture contents in the large shaded bins and the small bins of the two types. The data are arranged in groups according to the initial wheat moisture content.

As stated on page 61 the wheat in the large shaded bins, B–3, B–4, and B–25, was sour when sampled on April 23, 1938, and little difference could be seen in the quality of the wheat stored at the various initial moisture contents. Of the wheat stored in the 20-bushel plain metal bins, that in bin B–15, with an initial moisture content of 15.5 percent, turned sour in July 1938, about 100 days later than its companion large bin, and that in bins B–16 and B–17, initial moisture content 14.2 and 14.6 percent, remained in storage without developing an abnormal odor until August 19, 1938. The small shaded bin, B–13,

TABLE 15.—*Comparison of changes, in large and small bins, in wheat moisture content, temperature, odor, test weight, percent germination, and fat acidity at College Park in 1937*

Date sampled	Storage period	Wheat moisture content			Wheat temperature [1]			Wheat odor			Test weight per bushel			Germination			Fat acidity		
		Large,[2] shaded	Small,[3] shaded or insulated	Small,[4] plain metal	Large,[2] shaded	Small,[3] shaded or insulated	Small,[4] plain metal	Large,[2] shaded	Small,[3] shaded or insulated	Small,[4] plain metal	Large,[2] shaded	Small,[3] shaded or insulated	Small,[4] plain metal	Large,[2] shaded	Small,[3] shaded or insulated	Small,[4] plain metal	Large,[2] shaded	Small,[3] shaded or insulated	Small,[4] plain metal
	Days	*Percent*	*Percent*	*Percent*	*°F.*	*°F.*	*°F.*				*Pounds*	*Pounds*	*Pounds*	*Percent*	*Percent*	*Percent*	*Units*	*Units*	*Units*
WHEAT STORED AT INITIAL MOISTURE CONTENT OF 15.5 PERCENT (Bins B-25, B-13, B-15)																			
July 29, 1937	0	15.4	15.5	15.5	76	74	78	Natural	Natural	Natural	57.3	57.2	57.3	85	82	85	16	14	17
Apr. 23, 1938	268	15.5	15.5	15.0	51	56	59	Sour	do	do	56.0	55.7	56.0	[5] 53	63	46	[5] 26		[5] 30
June 4, 1938	310		15.5	14.7		75	75		do	do		55.6	56.2		48	44			
July 28, 1938	364		15.5	14.8		94	88		do	Sour		55.4	55.8		8	14		41	40
Aug. 25, 1938	392		15.2			84			do			55.4			14			41	
Sept. 23, 1938	421		15.2			69			Sour			55.0			8			47	
WHEAT STORED AT INITIAL MOISTURE CONTENT OF 14.6 PERCENT (Bins B-4, B-10, B-17)																			
July 23, 1937	0	14.7	14.6	14.6	78	78	79	Natural	Natural	Natural	56.8	56.4	56.8	89	87	89	17	16	21
April 23, 1938	274	14.7	14.9	14.3	50	57	59	Sour	do	do	56.0	56.0	55.6	58	43	40	[5] 25	[5] 29	[5] 28
June 4, 1938	316		14.8	14.0		76	74		do	do		56.0	55.6		19	45			
July 22, 1938	364		14.2	14.0		95	88		Sour	do		54.6	55.3		7	16		39	40
Aug. 19, 1938	392			14.1			85			Sour			55.0			8			40
WHEAT STORED AT INITIAL MOISTURE CONTENT OF 14.2 PERCENT (B-3, B-11, B-16)																			
July 23, 1937	0	14.2	14.2	14.2	79	78	79	Natural	Natural	Natural	57.4	57.3	57.3	91	86	86	14	15	13
Apr. 23, 1938	274	14.4	14.5	13.9	51	58	59	Sour	do	do	56.3	56.3	56.8	73	58	53	[5] 26	[5] 23	[5] 23
June 4, 1938	316		14.3	13.8		76	71		do	do		56.2	57.0		43	35			
July 26, 1938	368		14.2	13.7		98	84		Sour	do		56.0	57.0		21	24		34	29
Aug. 19, 1938	392			13.8			84			Sour			57.0			10			30

[1] Average temperature at bin center for month in which sample was taken.

[2] Large shaded bin B-25 contained wheat of 15.5 percent initial moisture content; bin B-4 wheat of 14.7 percent moisture; and bin B-3 wheat of 14.2 percent moisture.

[3] Small shaded bin B-13 filled with wheat containing 15.5 percent moisture and bin B-11 with wheat containing 14.2 percent moisture. Small insulated bin B-10 filled with wheat containing 14.6 percent moisture.

[4] Small plain metal bin B-15 filled with wheat containing 15.5 percent moisture; B-17 with wheat containing 14.6 percent moisture; and B-16 with wheat containing 14.2 percent moisture.

[5] Determinations made on samples drawn May 16, 1938.

was very effective in prolonging the storage period of the 15.5-percent-moisture-content wheat, while the insulation of bins B–10 and B–11 apparently had the opposite effect, the wheat going out of condition sooner than in the plain metal bins. The wheat moisture changes within the bin were less in the small insulated and shaded bins than in the small plain metal bins.

Ventilation of Bins [7]

1936 TESTS

In 1936, two naturally ventilated wood bins, B–6 and B–8, were tested. Bin B–6 was the west half of the 10-by-10-foot granary which also housed unventilated bin B–5, and B–8 the west half

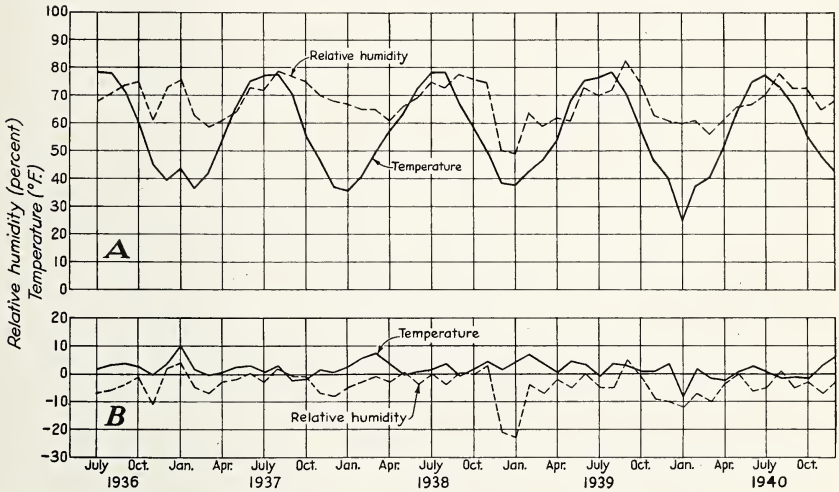

Figure 22.—Diagrams of the large ventilated bins tested at College Park: *A*, 1936; *B*, 1937.

of the granary of which B–7 was the east half. (Bins B–5 and B–7 were discussed on page 60.) The ventilating system installed in these bins consisted in each case of six horizontal flues each made of 1-by-4-inch boards set on edge 4 inches apart and covered on the upper surface with galvanized fly screen. The six horizontal flues were arranged in two vertical rows of three each, running north and south, with a horizontal distance between flue centers of 24 inches. The vertical distance between flue centers was 24 inches, with the bottom ones 18 inches above the floors. The flues in B–8 were open to the air on both ends, while in B–6 alternate ends were closed. There were also small screened openings in the gable ends of each bin, allowing a free circulation of air over the top of the grain. The ventilation systems are shown diagrammatically in figure 22. An unventilated bin, B–7, east of and adjoining bin B–8, with only a wood partition separating them, was used as a check bin.

[7] The Maryland ventilation experiments are here only briefly summarized, and brought up to date. For a more complete discussion see (*3*).

On July 11, 1936, each bin was filled to a depth of 6½ feet with 255 bushels of soft red winter wheat that had been well mixed. The average initial wheat moisture content in B–6 was 16.5 percent, and in B–7 and B–8, 16.4 percent, and the temperature of the wheat when placed in the bins averaged 86° F. The wheat temperature in the center of the unventilated check bin B–7 increased to 120° after 32 days' storage and an average sample taken on August 13 showed the wheat to be sour and heating. The wheat temperatures in the center of both ventilated bins increased steadily until, after 41 days in storage, in B–6 it reached 112°, and in B–8, after 39 days in storage, it reached 113°. These temperatures were taken within 8 inches of the ventilating flues. The outside temperatures then began to drop, and the bins cooled. On September 17, after 68 days in storage, the bins were emptied. The wheat when removed did not flow freely, but there was no caking around the flues. The grade-factor data, germination, and fat acidity of the wheat before and after storage are given in table 16. There was no difference in the amount of moisture (1.2 percent) removed from bins B–6 and B–8, and the fact that there appears to be a difference in favor of B–8 in regard to loss in germination or increase in percent damage, might be attributed to the fact that unventilated bin B–7, adjacent to B–8, was emptied twice for cooling and this may have resulted in lower average temperatures for B–8, which could not be directly credited to the ventilating system. The unventilated bin B–5, adjacent to B–6, also heated but was not moved for cooling and some of the heat from that bin probably passed through the partition to the wheat in B–6.

Although the two ventilated bins did not heat as quickly as did the unventilated bin filled with wheat of the same moisture content, these types of ventilation cannot be considered effective in storing wheat of moisture content approaching 16.5 percent in the Maryland area.

1938 TESTS

The College Park bins were remodeled in 1937 to shorten the length of the air path through the wheat. The six flues of B–6 were replaced with six layers or grids of flues with a vertical distance between layers of 10 inches, as shown in figure 22. Each layer was formed by a series of 1- by 2-inch by 10-foot pieces set on edge 3 inches on centers, with alternate spaces between the pieces covered top and bottom with galvanized fly screen. The layers were 10 feet long but only 3 feet wide, leaving an unventilated area 2 feet wide at the west wall. The first, third, and fifth layers from the bottom were connected at one end to a pressure-type ventilating cowl, kept headed into the wind by a vane. The other three layers were connected to a suction cowl. The air path was from the pressure cowl to the horizontal flues, through about 1 foot of wheat and out the suction cowl via the three layers of flues to which it was connected.

Unventilated bin B–7, (1936), the east half of another structure similar to that housing B–6, was remodeled for forced-ventilation studies. A floor of perforated metal was laid on 2 by 4's over the wooden floor, leaving an air chamber 3¾ inches deep and approximately the size of the floor area (5 by 10 feet). Two layers of horizontal flues, constructed the same as those in B–6, were installed, one 2 feet and the other 4½ feet above the floor. The lower grid was

connected to a suction-type ventilating cowl above the bin and the upper grid and the floor air chamber to a small multivane blower operated by a ¼-horsepower electric motor. A diagram of this system is shown in figure 22.

As a check on the performance of these two ventilated bins (B–6 and B–7), bin B–26, the west half of a 500-bushel round, shaded, metal bin with metal floor was used.

Bins B–6 and B–7 were filled on July 19, 1937, with 266 bushels each of 15.1 percent moisture content soft red winter wheat purchased on the terminal market at Baltimore. Check bin B–26 was filled with 180 bushels of wheat from the same lot but which averaged 15.2 percent moisture. Samples were taken from each bin weekly for several weeks, and then at longer intervals for moisture, grade, germination, and rancidity determinations. Data from samples taken at about 6-month intervals are given in table 16.

TABLE 16.—*Grade factor data, percent germination, and fat acidity of wheat stored in ventilated bins at College Park, in 1936 and 1937* [1]

Quantity of wheat (bushels)	Time in storage	Date	Wheat moisture content	Test weight per bushel	Dockage	Damage	Grade [2]	Odor	Germination	Fat acidity
	Days		*Pct.*	*Lbs.*	*Pct.*	*Pct.*			*Pct.*	*Units*
BINS FILLED IN 1936, BIN B–7 (UNVENTILATED CHECK BIN)										
271	2	July 13, 1936	16.4	59.0	------	0.2	Sample, Garlicky	Natural	83	[3] 17
271	33	Aug. 13, 1936	16.4	56.8	------	------	do	Sour	48	------
BINS FILLED IN 1936, BIN B–6 (HORIZONTAL FLUES, ALTERNATE ENDS CLOSED)										
255	2	July 13, 1936	16.5	59.0	------	0.4	Sample, Garlicky	Natural	94	[3] 18
255	33	Sept. 17, 1936	15.3	54.0	------	84.0	Sample, Garlicky, Tough.	Sour	0	------
BINS FILLED IN 1936, BIN B–8 (HORIZONTAL FLUES, BOTH ENDS OPEN)										
255	3	July 13, 1936	16.4	59.0	------	0.2	Sample, Garlicky	Natural	83	[3] 17
255	33	Sept. 17, 1936	15.2	55.6	------	52.0	Sample, Garlicky, Tough.	Sour	41	------
BINS FILLED IN 1937, BIN B–26 (UNVENTILATED CHECK BIN)										
180	0	July 21, 1937	15.2	57.8	0.3	1.8	3, Tough, Garlicky.	Natural	91	14
180	276	Apr. 23, 1938	15.3	57.5	.3	2.8	Sample, Garlicky, Tough.	Sour	66	[4] 29
BINS FILLED IN 1937, BIN B–6 (WIND-ASSISTED NATURAL VENTILATION)										
266	2	July 21, 1937	15.1	57.8	0.3	1.8	3, Tough, Garlicky.	Natural	92	15
266	36	Aug. 23, 1937	14.7	58.5	.3	1.9	2, Tough, Garlicky.	do	91	18
266	153	Dec. 18, 1937	14.2	58.4	.3	2.0	do	do	88	17
266	279	Apr. 23, 1938	14.3	58.2	.3	2.0	do	do	78	[4] 23
266	394	Aug. 16, 1938	13.4	58.6	.3	2.3	2, Garlicky	do	68	27
266	521	Dec. 21, 1938	13.4	58.5	.3	2.7	do	do	58	26
266	617	Mar. 27, 1939	13.6	58.0	.3	2.9	do	do	58	26
266	787	Sept. 13, 1939	13.4	57.5	.3	3.8	3, Garlicky	do	42	34
266	1,023	May 6, 1940	13.3	57.8	.3	4.0	do	do	52	32
266	1,326	Mar. 5, 1941	13.4	57.5	.3	4.8	do	do	28	38

See footnotes at end of table.

TABLE 16.—*Grade factor data, percent germination, and fat acidity of wheat stored in ventilated bins at College Park, in 1936 and 1937* [1]—Continued

BINS FILLED IN 1937, BIN B-7 (FORCE-VENTILATED)

Quantity of wheat, bushels	Time in storage	Date	Wheat moisture content	Test weight per bushel	Dockage	Damage	Grade [2]	Odor	Germination	Fat acidity
	Days		*Pct.*	*Lbs.*	*Pct.*	*Pct.*			*Pct.*	*Units*
266	0	July 19, 1937	15.1	57.6	0.3	1.7	3, Tough, Garlicky.	Natural	86	19
266	36	Aug. 23, 1937	14.4	58.6	.3	1.8	2, Tough, Garlicky.	do	90	19
266	153	Dec. 18, 1937	13.8	58.3	.3	2.0	2, Garlicky	do	85	18
266	279	Apr. 23, 1938	14.0	58.2	.3	2.0	do	do	72	[4] 24
266	394	Aug. 16, 1938	14.0	58.1	.3	2.4	do	do	50	27
266	521	Dec. 21, 1938	13.6	58.0	.3	2.8	do	do	42	29
266	617	Mar. 27, 1939	13.5	58.0	.3	3.0	do	do	36	29
266	787	Sept. 13, 1939	13.1	57.2	.3	3.9	3, Garlicky	do	30	33
266	1,023	May 6, 1940	13.2	57.5	.3	4.0	do	do	28	36
266	1,326	Mar. 5, 1941	13.0	57.0	.3	5.8	do	do	0	43

[1] All samples were averages of entire bin.
[2] All wheat of class Soft Red Winter and subclass Red Winter.
[3] Fat acidity calculated from acid value determination and average oil content of soft red winter wheat.
[4] Fat acidity of sample drawn May 16, 1938.

The wheat in the two ventilated bins, as measured by odor, was still in good condition on March 5, 1941, after 1,326 days in storage, while the unventilated wheat in bin B–26 was sour when sampled after only 276 days in storage. However, the fat acidity and germination percentages indicate that the wheat in both bins had deteriorated to a considerable extent, and a small portion of the grain on the floor in naturally ventilated bin B–6 had a slightly musty odor, not detectable in the average sample.

The pressure and suction cowls were left in place on bin B–6 for the entire storage period. The blower on B–7 was operated during the first 21 days of storage at times when the air relative humidity was below 60 percent, and again, except for rainy days, during the period February 27, 1939, to April 10, 1939, from about 8 a. m. to 6 p. m.

RESULTS OF MARYLAND VENTILATION TESTS

The weather at College Park was somewhat nearer normal than at the stations already discussed, as is shown by the graphs of the average monthly air temperatures and relative humidities, and their departures from normal (fig. 23). These records are from the Weather Bureau station at Washington, D. C. They show that the most dangerous season for keeping wheat in Maryland is the summer, for both the temperature and the relative humidity are normally higher than at any other season. However, conditions for drying during the winter are relatively favorable and if wheat can be kept from heating until cool weather it can be dried out slowly in ventilated bins before the next warm season.

The horizontal flues with 24- by 24-inch spacing were not effective in preventing heating of wheat of 16.4- and 16.5-percent moisture content in 1936, but probably would have kept wheat of 15 percent moisture. The closely spaced flues attached to pressure and suction cowls, as used in bin B–6, in 1937, were very effective in preventing heating and removing moisture, and would probably have succeeded

in holding sound wheat of 16-percent moisture. With this method of ventilation wheat of 15.1 percent moisture content was stored with-

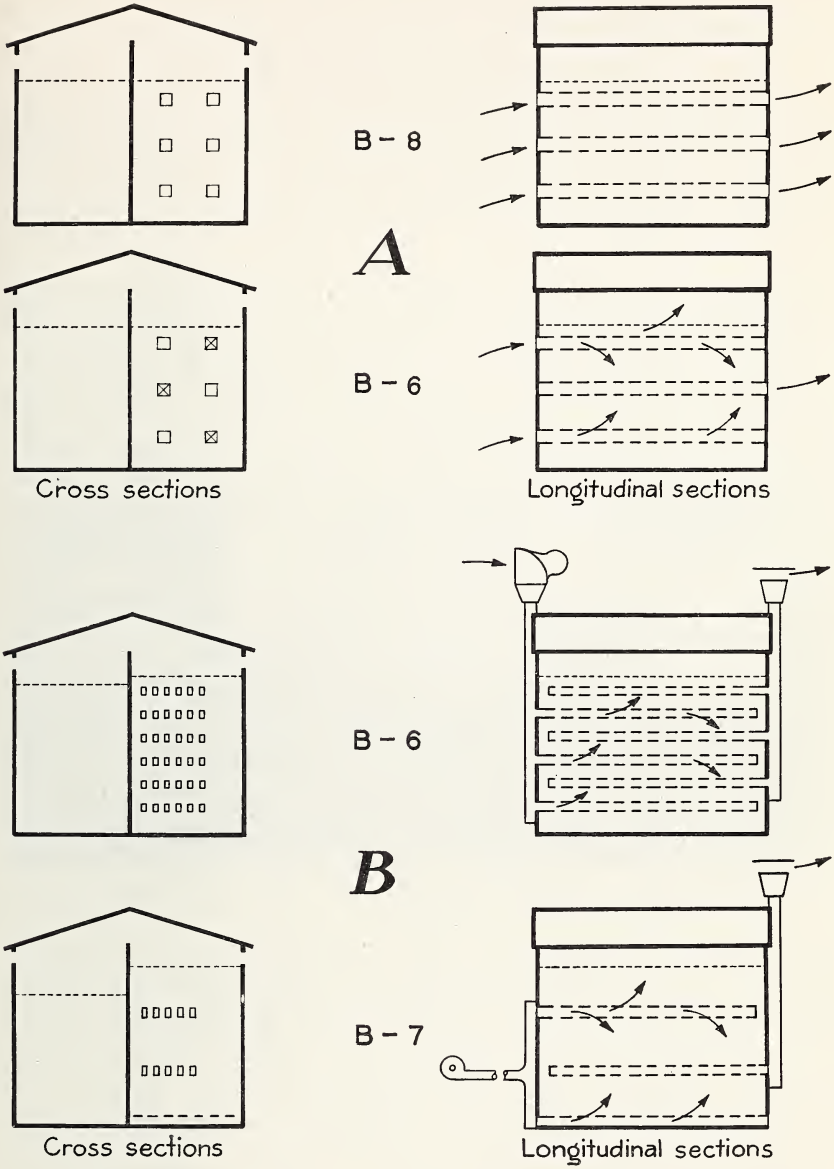

FIGURE 23.—Average monthly air temperature and percentage relative humidity (*A*), and the variation of these factors from the normal (*B*), at Washington, D. C., near College Park.

out development of an abnormal odor for over 3½ years although at the end of that time marked deterioration, as measured by germination and fat acidity, had occurred.

Forced ventilation during the driest parts of the days with air inlets and outlets arranged to provide escape for the air after travel through about 2 feet of wheat, was also quite satisfactory, but might not be dependable in seasons of higher relative humidity.

WHEAT STORAGE IN ILLINOIS

Since the facilities of the University of Illinois were available at Urbana, that location was selected for investigations of wheat storage in Illinois. Several corncribs, of about 300-bushel capacity each, mounted on flanged wheels so that they could be moved over a track to scales for weighing (fig. 24), were remodeled for wheat storage as

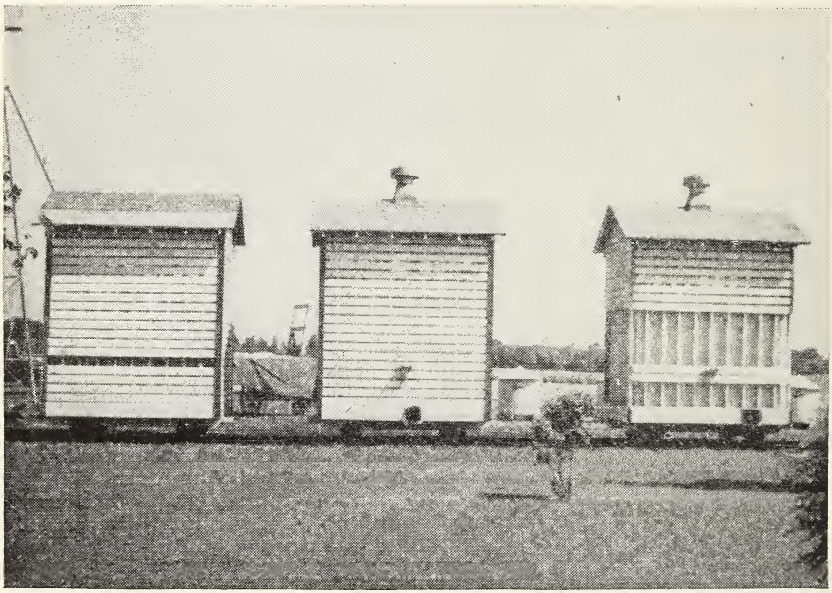

FIGURE 24.—Movable corncribs remodeled and used for wheat-storage studies at Urbana.

described in the following discussion. The track, scales, and movable cribs were in a well-drained location, exposed to the wind from the north, west, and east, but sheltered by large buildings about 100 feet to the south. They were exposed to the sun from all directions, but shaded each other in the early morning and late afternoon. As at the other stations, a number of small 20-bushel bins were also used in the tests. These could not be moved onto the scales for weighing.

EFFECT OF WHEAT MOISTURE CONTENT ON STORAGE IN UNVENTILATED BINS

Four of the movable corncribs, U–1, U–2, U–3, and U–4 were remodeled for unventilated wheat-storage tests in 1936. The original walls of the cribs were of 1- by 6-inch beveled boards, set about 1 inch apart on the north and south sides, and of 1- by 6-inch tongue-

and-groove boards set tight on the east and west ends. These boards were removed from bin U–1 and 26-gage galvanized sheet steel nailed to the inside of the studs. The studs were then painted white to reflect the sun as much as possible. The inside measurements of the bin were 7 feet wide (north to south) and 9 feet long (east to west).

The outside boards were not removed from the other cribs. Bin U–2 was lined on the inside of the studs with ½-inch insulation board nailed to 1- by 2-inch horizontal nailing strips and U–3 and U–4 with tongue-and-groove boards. As one end of both U–3 and U–4 was ventilated with horizontal flues and the unventilated ends were used as a check on the ventilation method, they are discussed on page 86.

Bins U–1 and U–2 (as well as U–3, with one end ventilated) were filled July 1, 1936, from a car of well-mixed soft red winter wheat averaging 15.7 percent moisture content. The initial wheat temperature of 88° F. at the center of bin U–1 increased steadily to 121° by July 21, when the wheat was moved to a transfer bin by shoveling and returned to U–1 on July 22. During this 20-day storage period the average wheat temperature had increased from 85° to 92°. The moving lowered the average temperature only 4°, but reduced the center temperature to 88°, a 33° drop. The average wheat moisture content lowered to 15.0 percent. By July 31 the temperature at the bin center had increased again to 100° F. and, because a musty odor appeared to be developing, the wheat was moved to the transfer bin a second time and returned to U–1 on August 4. An average sample taken on August 10 did not have an abnormal odor, but the percent total damage had increased to 9.5 from the original 2.7. A sample drawn September 22, 1936, however, was musty and the total damage had increased to 30 percent. Other grade data for these samples are given in table 17.

The wheat in bin U–2, with the ½-inch insulation board walls shaded by the original corncrib sides, went through much the same reactions and was treated in the same manner, as the wheat in bin U–1. The wheat was moved on July 22, when the temperature at the bin center was 120° F. and was returned to U–2 on July 23. The second moving and turning process did not take place until August 31, when the wheat at the bin center had reached 110° F. After moving the average wheat temperature was 90° and moisture content 13.8 percent.

Insects were observed in both bins but the infestation was not great enough to cause noticeable damage to the wheat by September 22. However, larvae honeycombed the insulation board of U–2 very badly.

The tests with bins U–1 and U–2 in 1936 showed very clearly that wheat of 15.7 percent moisture content could not be stored with safety in that area in ordinary bins. In 1937 the sheet-metal and insulation-board linings were removed from bins U–1 and U–2 and replaced with 1- by 6-inch tongue-and-groove boards. The beveled side boards and tongue-and-groove end boards were also renailed on the outside of the studs of U–1, leaving it as it was originally. On July 16, 1937, both bins were filled with wheat having an average moisture content of 14.2 percent. During filling 13 pounds of lime-sulfur was mixed with the wheat in U–1 and 20 pounds of pyrethrum compound with that in U–2. The wheat, averaging about 85° F. when placed in the bin, cooled slowly and no indication of heating was observed during the 69 days of storage. When the bin was emptied on September 23, 1937, the

TABLE 17.—*Grade data, days in storage, and quantity of wheat stored in unventilated large movable bins at Urbana*

Sample type	Quantity of wheat	Time in storage	Date	Wheat moisture content	Test weight per bushel	Dockage	Damage	Grade [1]	Odor	Germination	Fat acidity
	Bushels	*Days*		*Percent*	*Pounds*	*Percent*	*Percent*			*Percent*	*Units*
BIN U-1—GALVANIZED SHEET METAL, OUTSIDE CRIBBING REMOVED, 1936											
Average	298	1	July 3, 1936	15.7	61.0		2.7	Sample, Garlicky	Natural	84	
BIN U-1 AFTER MOVING ON JULY 21 AND JULY 31, 1936											
Average [2]	298	6	Aug. 10, 1936	14.2	60.0		9.5	4, Light Garlicky, Tough	Natural		
Do	298	49	Sept. 22, 1936	13.8	59.7		30.0	Sample, Weevily, Light garlicky.	Musty		
BIN U-2—½-INCH INSULATION BOARD, CRIBBING NOT REMOVED, 1936											
Average	294	1	July 3, 1936	15.7	61.0		2.0	Sample	Natural	83	
BIN U-2, AFTER MOVING ON JULY 22 AND AUG. 31, 1936											
Average [2]	294	1	Sept. 1, 1936	13.8	60.0	.4	16.0	Sample, Light garlicky	Natural		
Do	294	22	Sept. 22, 1936	13.6	60.0		17.0	do	Musty		
BIN U-1—WOOD CONSTRUCTION (WHEAT MIXED WITH LIME SULFUR), 1937											
Average	277	1	July 17, 1937	14.2	57.7	0.3	0.5	3, Tough, Light garlicky	Natural	81	16
Do	277	34	Aug. 19, 1937	14.3	57.0	.3	.5	3, Tough, Light garlicky, Limed.	do	80	15
Do.[3]	277	69	Sept. 23, 1937	14.2	57.0	.4	.7	3, Tough, Light garlicky, Limed, Weevily.	do	72	20

BIN U-2—WOOD CONSTRUCTION (WHEAT MIXED WITH PYRETHRUM), 1937

Average	239	1	July 17, 1937	14.2	57.2		0.4	3, Tough, Light garlicky	Natural	80	15
Do	239	34	Aug. 19, 1937	14.3	57.0	0.3	.5	do	do	82	17
Do.[3]	239	69	Sept. 23, 1937	14.2	57.1	.4	.7	do	do	80	18

BIN U-4—WOOD CONSTRUCTION, 1938

Average	296	1	July 5, 1938	14.7	59.8	0.4		2, Tough, Light garlicky	Natural	87	17
Do	296	32	Aug. 4, 1938	14.8	59.7	.4		do	do	90	19
Do	296	59	Aug. 31, 1938	14.8	59.6			do	Fumigant	86	21
Do	296	71	Sept. 12, 1938	14.7	59.5			Sample, Tough, Light garlicky.	Slightly musty	80	21
Inferior [4]	67	71	do	15.0	57.7	.5	10.0	Sample, Tough, Light garlicky, Weevily.	Musty	46	32
Remainder [5]	229	71	do	14.6	59.5			2, Tough, Light garlicky, Weevily.	Natural	77	20

[1] All wheat of class Soft Red Winter and subclass Red Winter.
[2] After wheat was moved twice.
[3] Bins emptied before development of abnormal odor in wheat.
[4] Inferior portion amounting to about 67 bushels.
[5] Remainder of wheat, excluding all inferior portions.

quality had lowered only slightly as shown by the grade data in table 17. Definite conclusions as to the maximum length of time wheat with this moisture content can be safely stored cannot be made on the basis of these tests because of the admixtures and because the bins were emptied so quickly. However, the fact that the cool fall temperatures had arrived and the wheat was still in good condition and that the 14.2-percent wheat in the unventilated end of 1936 bin U–4, discussed on page 86 had also remained in storage until the following summer before going out of condition, makes it fairly safe to assume that the wheat in bins U–1 and U–2 could have been stored safely until the following spring.

Only one of the movable 300-bushel bins, U–4, was filled with wheat of the 1938 crop. In construction U–4 was identical with U–1 and U–2 just discussed under the 1937 experiments. It was filled to a depth of 5.9 feet on July 4, 1938 with 296 bushels of wheat from a carload having an average moisture content of 14.7 percent and an average temperature of 82° F. The temperature increased in the north part of the bin, about 2 feet from the wall, to 105° on September 12, 1938, when the bin was emptied. The moisture content of the inferior portion, amounting to about 70 bushels, was 15 percent compared to 14.6 percent for the balance of the bin. As shown by the grade data in table 17 the average sample from the bin at this time had a slightly musty odor.

The results observed in the tests of wheat stored in the 300-bushel unventilated bins at Urbana show that wheat with a moisture content of 14.7 percent definitely cannot be stored at Urbana for longer than 2 months if placed in storage during July, and that for safe storage for 1 year the maximum allowable moisture content probably is not over 14.2 percent.

Tests With 20-Bushel Bins

As at the other stations, 10 small 20-bushel bins, 5 of plain metal (U–11, U–12, U–13, U–14, and U–15) and 5 of insulated metal (U–21, U–22, U–23, U–24, and U–25) were filled with wheat at Urbana in 1936. Both types of bins were 40 inches in inside diameter and 36 inches high. The insulated bins had walls and bottom insulated with 3 inches of glass wool and covers of 2 thicknesses of 1-inch insulation board.

The bins were divided into pairs, one insulated and one plain metal, and each pair filled with wheat of a different moisture content. Thus, bins U–11 and U–21 received wheat with 13.0 to 13.3 percent moisture, U–12 and U–22, 15.2 percent, U–13 and U–23, 15.6 percent and U–15 and U–25, 17.6 percent.[8] Average grade samples were taken when the bins were first filled, but the second sampling was delayed until 88 days later for the 13-percent-moisture-content wheat and 82 days later for the other bins. At the second sampling all except the 13-percent-moisture-content wheat had a musty odor. Complete grade factor data for both initial and last samples are given in table 41 of the appendix. (*4*)

[8] Peat moss was added to the wheat stored in bins U–14 and U–24. These bins are discussed on page 128.

In 1937 the small bins used in 1936 were emptied, renumbered, and refilled. The bins can be classified according to type or construction, as follows:

1. Plain metal—bins U–11, U–12, and U–13 were of plain galvanized sheet steel, 40 inches in diameter and 36 inches high, with conical metal roofs.
2. Insulated metal—the walls and floor of bins U–23, U–24, and U–25 were insulated with 3 inches of glass wool.
3. Shaded—bins U–14, U–15, and U–16 were of plain metal, shaded from the sun on the top, east, south, and west sides by walls and covers of wood.

It was planned to place wheat of 13.5 percent moisture content in one bin of each type, that of 14.0 percent in another group of three bins, and that of 14.5 percent in a third group. However, wheat with the exact moisture contents desired could not be obtained so the initial moisture contents varied somewhat. In table 18, the wheat moisture, temperature, odor, germination, and fat acidity of the initial, and successive samples taken over a 3½ year period, are given for the nine bins. Although the insulated bins were left in storage only 78 days the table illustrates very well the differences in the changes observed in wheat condition when stored in plain metal or shaded 20-bushel bins.

The first and most pronounced difference noted between the two types of construction is that in wheat moisture content during the storage period. The wheat in the plain metal bins varied much more in moisture content than did that in the shaded bins, and in the 3½-year period dropped 0.6 percent in the case of the wheat originally at 13.8 percent moisture content, and 1.4 percent in the case of wheat of 14.7 percent moisture. On the other hand the wheat in the shaded bins varied little in moisture content, showing an actual slight increase at the end of 3½ years. The moisture decrease in the plain metal bins was probably caused by the more rapid heating and cooling of the wheat than in the insulated bins. While the groupings into sections are correct on the basis of initial wheat moisture content, it is evident that on the basis of average moisture content over the 3½-year period shaded bin U–14, with an average moisture content for the storage period of 13.4 percent, should be compared with plain metal bin U–12, with an average period moisture content of 13.2 percent. Similarly, shaded bin U–15, had the same period average moisture content (14.0 percent) as plain metal bin U–13.

Because in large bins this loss of moisture would undoubtedly not be as great as from the 20-bushel bins, the comparison on the basis of period average moisture content is probably more accurate than on the basis of initial moisture content. Such a comparison shows that the rate of deterioration as indicated by fat acidity was slightly greater both at 13.2 to 13.4 percent average moisture content (comparing bins U–12 and U–14) and at 14 percent (comparing bins U–13 and U–15) in the plain metal bins. However, at 13.2 to 13.4 percent moisture content the germination drop in the shaded bins was slightly greater and at 14 percent moisture content considerably less in the shaded than in the plain metal bins. The only wheat developing an abnormal odor in the 1,275-day storage period was that stored in bin U–16, a shaded bin.

TABLE 18.—*Moisture content, temperature, odor, percent germination, and fat acidity of wheat stored in plain, insulated, and shaded 20-bushel metal bins, at various initial moisture contents, at Urbana, in 1937*

WHEAT OF APPROXIMATELY 13 PERCENT ORIGINAL MOISTURE CONTENT

Date sampled	Time in storage	Wheat moisture content			Wheat temperature [1]			Wheat odor			Germination			Fat acidity		
		U-11 plain	U-23 [2] insulated	U-14 shaded	U-11 plain	U-23 [2] insulated	U-14 shaded	U-11 plain	U-23 [2] insulated	U-14 shaded	U-11 plain	U-23 [2] insulated	U-14 shaded	U-11 plain	U-23 [2] insulated	U-14 shaded
	Days	*Percent*	*Percent*	*Percent*	*°F.*	*°F.*	*°F.*				*Percent*	*Percent*	*Percent*	*Units*	*Units*	*Units*
July 8, 1937	1	12.8	13.5	13.1	86	84	87	Natural	Natural	Natural	84	89	84	16	15	19
Aug. 5, 1937	29	12.6	13.4	13.0	81	77	74	do	do	do	85	81	85	18	[3] 17	16
Sept. 23, 1937	78	12.4	12.9	12.9	66	68	60	do	do	do	86	77	87	18	19	18
Jan. 20, 1938	197	12.8		13.3	33		32	do		do	82		80	19		17
July 6, 1938	364	12.4		13.4	76		70	do		do	79		72	23		21
Feb. 1, 1939	574	12.5		13.2	(4)		(4)	do		do	87		65	24		22
Aug. 1, 1939	755	12.4		13.6	80		76	do		do	81		63	25		23
Jan. 2, 1940	909	12.7		13.4	(4)		(4)	do		do	82		70	28		28
July 2, 1940	1,090	12.4		13.4	72		69	do		do	78		58	30		28
Jan. 3, 1941	1,275	13.1		15.0	38		37	do		do	76		58	34		33
Average		12.6		13.4												

WHEAT OF APPROXIMATELY 14 PERCENT ORIGINAL MOISTURE CONTENT

		U-12	U-24 [2]	U-15	U-12	U-24 [2]	U-15	U-12	U-24 [2]	U-15	U-12	U-24 [2]	U-15	U-12	U-24 [2]	U-15
July 8, 1937	1	13.8	13.8	14.1	83	83	83	Natural	Natural	Natural	80	86	84	16	15	15
Aug. 5, 1937	29	13.6	13.4	14.0	81		74	do	do	do	82	85	84	19	18	16
Sept. 23, 1937	78	13.2	13.1	13.9	66		60	do	do	do	87	87	82	18	19	18
Jan. 20, 1938	197	13.8		14.4	33		32	do		do	81		80	18		17
July 6, 1938	364	13.0		14.1	77		72	do		do	76		76	26		22
Feb. 1, 1939	574	13.0		14.0	(4)		(4)	do		do	76		79	25		24
Aug. 1, 1939	755	12.9		14.0	80		74	do		do	70		70	27		25
Jan. 2, 1940	909	13.0		14.0	(4)		(4)	do		do	78		78	30		27
July 2, 1940	1,090	12.7		13.5	75		69	do		do	68		63	30		36
Jan. 3, 1941	1,275	13.0		14.3	38		37	do		do	58		68	35		32
Average		13.2	13.4	14.0												

WHEAT OF APPROXIMATELY 14.5 PERCENT ORIGINAL MOISTURE CONTENT

		U-13	U-25 [2]	U-16	U-13	U-25 [2]	U-16	U-13	U-25 [2]	U-16	U-13	U-25 [2]	U-16	U-13	U-25 [2]	U-16
July 8, 1937	1	14.7	14.3	14.6	87	82	86	Natural	Natural	Natural	[5] 80	80	80	15	15	15
Aug. 5, 1937	29	14.5	14.0	14.7	80	78	74	do	do	do	78	79	76	17	19	[3] 17
Sept. 23, 1937	78	13.8	13.7	14.5	67	67	61	do	do	do	79	82	82	18	19	18
Jan. 20, 1938	197	14.7		14.9	32		32	do		do	76		70	19		18
July 6, 1938	364	13.9		14.6	77		73	do		do	64		72	26		23
Feb. 1, 1939	574	14.5		14.8	([4])		([4])	do		do	50		65	28		24
Aug. 1, 1939	755	13.6		14.6	80		75	do		do	26		49	31		25
Jan. 2, 1940	909	13.7		14.7	([4])		([4])	do		Storage	32		52	33		27
July 2, 1940	1,090	13.0		13.9	75		68	do		Natural	18		30	36		29
Jan. 3, 1941	1,275	13.3		14.9	38		37	do		Cofo [6]	17		20	38		32
Average		14.0		14.6												

[1] Temperature at center of bin.
[2] Bin emptied Sept. 23, 1937.
[3] This is fat acidity determination for date of Aug. 19, 1937.
[4] Below 32° F.
[5] This is germination determination for sample drawn July 16, 1937.
[6] Commercially objectionable foreign odor.

Fumigation Tests in 20-Bushel Bins

In 1938, 12 small plain metal bins were constructed and numbered U–30 through U–41. In cooperation with the Natural History Survey of the State of Illinois [9] a series of tests were made in the small bins to determine the effectiveness of various fumigants, applied at different rates, in preventing and controlling insect infestation, and to note the effect, if any, of the fumigant on the quality of the wheat.

The bins were filled on July 1, 1938, with wheat varying in moisture content between individual bins from 11.3 to 14.2 percent. On August 26 insects were buried in cloth bags in each bin to a depth of 15 inches below the upper wheat surface. Liquid insecticides (carbon disulfide, mixture of carbon disulfide and carbon tetrachloride in ratio of 1 to 3, chlorasol, chloropicrin, and methyl bromide) were then poured over the grain surface in 10 of the bins and the bins each tightly covered with a tarpaulin. Bins U–34 and U–35 were used as checks and were not fumigated. The tarpaulins were removed after 5 days, and at the same time samples of wheat for milling and baking, germination, fat acidity, and insect abundance determinations were taken from each bin. This sampling was repeated 5 days later. The results of the tests are given in table 19 as are the fumigants and amounts placed in each bin.

As would be expected, the fumigant had no effect on the wheat moisture content. Methyl bromide, used at two different rates, in bins U–36 and U–39, greatly reduced the germination percentage, and apparently chloropicrin applied in bins U–30 and U–32 at the rate of 3 pounds per 1,000 bushels also had a harmful effect on viability although not to such a great extent. The other fumigants did not affect germination in any way.

From the tests there is no evidence that the fat acidity of the wheat was affected by any of the fumigants. On the other hand, all baking samples made on wheat from fumigated bins showed a slight off taste in the bread, with a normal taste in the bread made from the unfumigated bins U–34 and U–35.

No insects were found in the samples taken from the bins fumigated with chloropicrin, with a mixture of 75 percent ethylene dichloride and 25 percent carbon tetrachloride, or methyl bromide, indicating a complete kill in these small bins. The mixture of carbon disulfide and carbon tetrachloride used in bins U–37 and U–40 at the rate of 20 pounds per 1,000 bushels had little effect on insect infestation, and the unmixed carbon disulfide was effective in only one bin, U–31. The higher moisture content of the wheat in bin U–38 may partially explain the ineffectiveness of the fumigant.

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[9] Dr. M. D. Farrar, of the Natural History Survey, made the fumigation tests and examined the samples to determine the effectiveness of the various fumigants.

TABLE 19.—*Quality of wheat and bread, and abundance of insects, before and after fumigation on Aug. 26, 1938, with various fumigants, at Urbana*

Date	Wheat moisture	Germination	Fat acidity	Baking data[1]					Live insects in bag when graded[2]
				Loaf volume	Color of crumb	Grain and texture	Crust color	Odor or taste	
	Percent	*Percent*	*Units*	*C. c.*					
NO FUMIGANT, BIN U-34									
July 7, 1938	13.0	67	19.8						
Aug. 26, 1938	12.7	51	22.5	466	50 creamy yellow	55, Poor	Light brown	Odor normal in flour, dough, and bread	Abundant (caked).
Aug. 31, 1938	12.9	61	22.0	458	45 creamy yellow	50, Poor	do	do	Do.
Sept. 6, 1938	12.9	62	21.2	480	50 creamy yellow		Pale	do	Do.
NO FUMIGANT, BIN U-35									
July 7, 1938	13.1	63	19.1						
Aug. 26, 1938	13.0	57	22.5	469	50 creamy yellow	55, Poor	Light brown	Odor normal in flour, dough, and bread	Abundant (caked).
Aug. 31, 1938	13.0	60	21.5	460	do	50, Poor	do	do	Do.
Sept. 6, 1938	12.8	65	22.0	463	45 creamy yellow	50, Poor	Pale	do	Do.
FUMIGATED WITH CHLOROPICRIN (LIQUID) AT RATE OF 3 POUNDS PER 1,000 BUSHELS, BIN U-30									
July 7, 1938	12.7	86	17.2						
Aug. 26, 1938	12.6	77	18.7	503	55 creamy yellow	65, Fair	Light brown	Odor normal in flour, dough, and bread	Abundant (caked).
Aug. 31, 1938	12.6	51	23.7	474	50 creamy yellow	55, Poor		Slight off taste in bread	None.
Sept. 6, 1938	12.7	50	17.3						Do.
FUMIGATED WITH CHLOROPICRIN (LIQUID) AT RATE OF 3 POUNDS PER 1,000 BUSHELS, BIN U-32									
July 7, 1938	11.3	87	19.5						
Aug. 26, 1938	11.4	84	17.4	466	55 creamy yellow	55, Poor	Light brown	Odor normal in flour, dough, and bread	Abundant (caked).
Aug. 31, 1938	11.4	52	17.7	461	50 creamy yellow	50, Poor	Pale	Slight off taste in bread	None.
Sept. 6, 1938	11.4	68	15.4	455	do	50, Poor	do	do	Do.

See footnotes at end of table.

TABLE 19.—*Quality of wheat and bread, and abundance of insects, before and after fumigation on Aug. 26, 1938, with various fumigants, at Urbana*—Continued

Date	Wheat moisture	Germination	Fat acidity	Baking data [1]					Live insects in bag when graded [2]
				Loaf volume	Color of crumb	Grain and texture	Crust color	Odor or taste	
	Percent	*Percent*	*Units*	*C. c.*					
FUMIGATED WITH "CHLORASOL" AT RATE OF 50 POUNDS PER 1,000 BUSHELS, BIN U-33									
July 7, 1938	11.3	87	20.3						
Aug. 26, 1938	11.4	83	16.7	455	55 creamy yellow	55, Poor	Light brown	Odor normal in flour, dough, and bread	Abundant (caked).
Aug. 31, 1938	11.3	80	15.4	458	50 creamy yellow	55, Poor	do	Slight off taste in bread	None.
Sept. 6, 1938	11.4	85	15.8	442	do	45, Poor	Brown	do	Do.
FUMIGATED WITH "CHLORASOL" AT RATE OF 50 POUNDS PER 1,000 BUSHELS, BIN U-41									
July 11, 1938	13.4	88	17.7						
Aug. 26, 1938	13.2	86	16.5	495	55 creamy yellow	60, Fair	Light brown	Odor normal in flour, dough, and bread	Abundant (caked).
Aug. 31, 1938	13.2	88	18.2	492	do	60, Fair	do	Slight off taste in bread	None.
Sept. 7, 1938	13.2	90	17.1						Do.
FUMIGATED WITH METHYL BROMIDE AT RATE OF 300 POUNDS PER 1,000 BUSHELS, BIN U-36									
July 11, 1938	12.5	80	19.5						
Aug. 26, 1938	12.3	78	15.8	503	60 creamy yellow	70, Fair	Brown	Odor normal in flour, dough, and bread	Abundant (caked).
Aug. 31, 1938	12.5	0	16.6	500	55 creamy yellow	65, Fair	do	Slight off taste in bread	None.
Sept. 6, 1938	12.5	2	16.9	517	do	70, Fair	Light brown	do	Do.
FUMIGATED WITH METHYL BROMIDE AT RATE OF 10 POUNDS PER 1,000 BUSHELS, BIN U-39									
July 9, 1938	14.2	92	17.3						
Aug. 26, 1938	14.0	82	16.6	483	55 creamy yellow	55, Poor	Brown	Odor normal in flour, dough, and bread	Abundant (caked).
Aug. 31, 1938	14.1	12	17.6	471	50 creamy yellow	55, Poor	Light brown	Slight off taste in bread	None.
Sept. 7, 1938	14.0	15	19.3	474	do	55, Poor	Pale	do	Do.

FUMIGATED WITH CARBON DISULFIDE AND CARBON TETRACHLORIDE (1 TO 3 RATIO) AT RATE OF 20 POUNDS PER 1,000 BUSHELS, BIN U-37									
July 11, 1938	12.4	84	17.3						
Aug. 26, 1938	12.3	72	16.0	506	60 creamy yellow	70, Fair	Brown	Odor normal in flour, dough, and bread	Abundant (caked).
Aug. 31, 1938	12.4	80	15.4	506	55 creamy yellow	70, Fair	do	Slight off taste in bread	Abundant.
Sept. 7, 1938	12.3	85	17.5	517	60 creamy yellow	70, Fair	Light brown	do	Abundant (caked).
FUMIGATED WITH CARBON DISULFIDE AND CARBON TETRACHLORIDE (1 TO 3 RATIO) AT RATE OF 20 POUNDS PER 1,000 BUSHELS, BIN U-40									
July 11, 1938	13.4	92	16.0						
Aug. 26, 1938	13.2	86	14.4	486	55 creamy yellow	60, Poor	Brown	Odor normal in flour, dough, and bread	Abundant (caked).
Aug. 31, 1938	13.2	85	17.1	480	50 creamy yellow	60, Poor	Light brown	Slight off taste in bread	Abundant.
Sept. 7, 1938	13.3	88	17.0						Abundant (caked).
FUMIGATED WITH CARBON DISULFIDE AT RATE OF 10 POUNDS PER 1,000 BUSHELS, BIN U-31									
July 7, 1938	12.7	86	20.9						
Aug. 26, 1938	12.6	87	18.7	466	55 creamy yellow	60, Fair	Light brown	Odor normal in flour, dough, and bread	Abundant (caked).
Aug. 31, 1938	12.6	88	22.4	466	50 creamy yellow	55, Poor	do	Slight off taste in bread	None.
Sept. 6, 1938	12.6	88	18.0	460	do	55, Poor	Pale	do	Do.
FUMIGATED WITH CARBON DISULFIDE AT RATE OF 10 POUNDS PER 1,000 BUSHELS, BIN U-39									
July 9, 1938	14.2	94	19.4						
Aug. 26, 1938	13.9	86	17.5	506	55 creamy yellow	55, Poor	Brown	Odor normal in flour, dough, and bread	Abundant (caked).
Aug. 31, 1938	14.0	77	18.2	468	50 creamy yellow	50, Poor	Light brown	Slight off taste in bread	Many.
Sept. 7, 1938	14.0	88	19.1						Abundant.

[1] The baking, germination, moisture, and fat acidity samples of Aug. 26, 1938 were taken immediately before fumigation on that date.

[2] The samples of grain and insects were removed from the bins on Aug. 26, Aug. 31, and Sept. 6 or 7. These were incubated and graded on Nov. 29, Oct. 24, and Oct. 24, respectively.

Ventilation of Bins (3)

Several of the 300-bushel movable corncribs were remodeled into various types of ventilated bins. The original walls were left in place and the inside of the studs lined with 1- by 6-inch tongue-and-groove boards to make a grain-tight bin. The ventilating systems were then installed.

1936 TESTS

Four cribs were remodeled in 1936 for ventilation tests—two for natural ventilation by horizontal flues, and two for forced ventilation with hot and cold air.

The west halves of bin U–3 and U–4 were fitted with six horizontal flues each, of the same type as were described in the North Dakota ventilation tests, page 25. The flues thus arranged gave natural ventilation to the west halves of both bins but no ventilation to the east halves.

On July 2, bin U–3, was filled to the 5-foot 8-inch level with 281 bushels of soft red winter wheat of 15.7 percent moisture content. The wheat in the approximate center of mass in each half had an initial temperature of 86° F. This rose rapidly in the unventilated half to 120° on July 20 when the wheat was moved for cooling, after only 18 days' storage. A sliding partition was inserted from the top between the ventilated and unventilated halves to hold the ventilated wheat in position during the unloading of the heating wheat. During the same 18-day period the highest temperature noted in the ventilated end of the bin was 92°. The wheat in the unventilated end of the bin was moved three times during the fall, each time because of heating. The ventilated bin was emptied on September 29, after being in storage 89 days without developing a musty odor. However, the grade, germination, and fat acidity data given in table 20 indicate that the wheat was not in good condition. During the storage period, 1.6 percent moisture was removed from the ventilated wheat.

Bin U–4, remodeled in exactly the same manner as U–3 except that one end of each flue was closed, was filled on July 3, 1936, with 281 bushels of 14.2-percent-moisture-content wheat. The grain was left in storage until September 23, 1937, a period of 447 days, at which time the wheat in the unventilated end had developed a musty odor. The ventilated wheat, however, was not musty, although showing marked deterioration as measured by grade factors, germination percentage, and fat acidity. The initial and final grade, germination, and fat acidity data are given in table 20.

Two of the movable corncribs, U–5 and U–6, were remodeled for forced ventilation of wheat. The walls were lined with 1- by 6-inch tongue-and-groove flooring, and an air chamber was formed on the bottom of each by laying a floor of perforated metal over 2- by 8-inch joists set on the old tight, wood floors. These chambers were arranged so that connections could be made, through ducts, to a supply of normal temperature air in the case of U–5, and to a source of heated air in the case of U–6.

Bins U–5 and U–6 were filled on July 3, 1936, from the same car of wheat as bin U–4. By volume, 301 bushels were stored in U–5 and 302 bushels in U–6. This filled each bin to a level of 5 feet 11 inches.

TABLE 20.—*Grade data, days in storage, and quantity of wheat stored in ventilated large bins at Urbana*

Sample type	Quantity of wheat	Time in storage	Date	Wheat moisture content	Test weight per bushel	Dockage	Damage	Grade [1]	Odor	Germination	Fat acidity
	Bu.	*Days*		*Pct.*	*Lb.*	*Pct.*	*Pct.*			*Pct.*	*Units*
BIN U-3—WEST HALF VENTILATED WITH HORIZONTAL FLUES, BOTH ENDS OPEN, 1936											
Average	[2] 281	2	July 3, 1936	15.7	61.0	0.6	2.4	Sample, Light garlicky	Natural	84	[3] 16
Do.[4]	281	90	Sept. 29, 1936	14.1	59.8	.5	18.0	Sample, Tough, Light garlieky, Weevily	do	17	[3] 49
BIN U-4—WEST HALF VENTILATED WITH HORIZONTAL FLUES, ONE END ONLY OPEN, 1936											
Average	[2] 281	2	July 4, 1936	14.2	61.6	0.5	1.2	1, Tough, Light garlicky	Natural	84	[3] 17
Do	281	89	Sept. 29, 1936	12.9	60.6	.4	1.7	1, Light garlieky, Weevily	do		[3] 22
Do	281	398	Aug. 4, 1937	13.7	59.7	.5	4.5	3	Slight weevily	70	25
Do.[4]	281	448	Sept. 23, 1937	13.6	59.5	.5	4.6	3, Weevily	Weevily	60	27
BIN U-4—UNVENTILATED EAST END, CHECK ON ABOVE, 1936											
Average	[2] 281	2	July 4, 1936	14.2	61.6	0.5	1.2	1, Tough, Light garlieky	Natural	84	[3] 17
Do	281	89	Sept. 29, 1936	14.1	60.6	.5	1.6	1, Tough, Light garlieky, Weevily	do		[3] 29
Do	281	398	Aug. 4, 1937	14.6	59.8	.4	7.0	3, Tough	Slight weevily	45	37
Do	281	447	Sept. 23, 1937	14.2	59.0	.5	12.2	Sample, Tough, Weevily	Musty	19	34
BIN U-5—FORCE VENTILATED FROM BOTTOM WITH NORMAL AIR, 1936											
Average	301	2	July 4, 1936	14.2	61.4	0.3	1.0	1, Tough	Natural	86	[3] 18
Do	301	89	Sept. 29, 1936	13.5	60.9	.4	1.5	1, Weevily	do		[3] 25
Do.[4]	301	348	June 15, 1937	14.7	60.0	.3	6.0	3, Tough	do	26	
BIN U-6—FORCE VENTILATED FROM BOTTOM WITH HEATED AIR, 1936											
Average	302	2	July 4, 1936	14.2	61.4	0.3	1.5	1, Tough	Natural	86	[3] 15
Do	302	89	Sept. 29, 1936	13.9	60.4	.5	1.7	1, Weevily	do		[3] 22
Do.[4]	302	348	June 15, 1937	14.7	59.8	.5	12.8	5, Tough	do	27	

See footnotes at end of table.

TABLE 20.—*Grade data, days in storage, and quantity of wheat stored in ventilated large bins at Urbana*—Continued

Sample type	Quantity of wheat	Time in storage	Date	Wheat moisture content	Test weight per bushel	Dockage	Damage	Grade [1]	Odor	Germination	Fat acidity
	Bu.	*Days*		*Pct.*	*Pct.*	*Pct.*	*Lb.*			*Pct.*	*Units*
BIN U-3—VENTILATED WITH 10 HORIZONTAL FLUES, 1937											
Average	284	2	July 12, 1937	17.2	56.0	0.5	0.6	Sample, Garlicky	Natural	66	19
Do	284	5	July 15, 1937	16.5	56.3	.6	.5	do	do	63	21
Do	284	19	July 29, 1937	16.5	55.2	.4	.5	do	do	46	37
Do	284	26	Aug. 5, 1937	16.6	55.0	.5	.9	do	Musty	36	42
BIN U-8—VENTILATED WITH 30 HORIZONTAL FLUES, 1937											
Average	305	2	July 12, 1937	17.0	56.0	0.5	0.7	Sample, Garlicky	Natural	70	21
Do	305	5	July 15, 1937	16.5	56.3	.5	.6	do	do	69	28
Do	305	26	Aug. 5, 1937	16.7	55.8	.4	.7	do	do	49	35
Do	305	33	Aug. 12, 1937	16.3	56.0	.3	.6	do	do	46	33
Do.[4]	305	40	Aug. 19, 1937	16.3	55.7	.4	2.6	do	do	37	38
BIN U-5—FORCE VENTILATED, AIR PATH THROUGH WHEAT 18 INCHES, 1937											
Average	284	0	July 16, 1937	16.3	54.5	0.6	3.0	Sample, Light garlicky, Treated	Natural	61	21
Do	284	20	Aug. 5, 1937	15.2	54.5	.5	2.7	4, Tough, Light garlicky, Limed		54	30
Do	284	62	Sept. 16, 1937	14.1	55.3	.4	5.1	do	Natural	53	33
Do.[4]	284	69	Sept. 23, 1937	13.7	55.3	.4	4.9	4, Light garlicky, Weevily, Limed	Lime	50	32
BIN U-6—FORCE VENTILATED (SEE TEXT FOR AIR-PATH LENGTH), 1937											
Average	276	1	July 17, 1937	15.9	56.3	0.5	0.4	Sample, Light garlicky	Natural	70	21
Do	276	20	Aug. 5, 1937	15.4	54.8	.5	.5	4, Tough, Light garlicky		51	30
Do	276	62	Sept. 16, 1937	13.3	56.3	.4	4.0	3, Light garlicky	Natural	48	33
Do.[4]	276	69	Sept. 23, 1937	12.5	56.6	.5	4.5	3, Light garlicky, Weevily	do	51	32

BIN U-2—THREE VERTICAL FLUES CONNECTED TO SUCTION COWL, 1938

Average	294	5	July 6, 1938	14.7	59.6	0.3	(5)	2, Tough, Light garlicky	Natural	86	16
Do	294	188	Jan. 5, 1939	14.6	59.3	.4	0.7	do	Fumigant	81	22
Do	294	370	July 6, 1939	15.0	58.5	.5	.9	do	Natural	43	27
Do	294	553	Jan. 5, 1940	14.2	58.2	.5	4.5	3, Tough, Light garlicky	do	68	26
Do	294	642	Apr. 4, 1940	15.0	57.7	.4	6.5	do	Fumigant	38	27
Do	294	731	July 2, 1940	14.6	58.0	.4	12.0	Sample, Tough, Light garlicky, Weevily	Musty		33

BIN U-3—8- BY 32-INCH VERTICAL FLUE, NO COWL, 1938

Average	286	4	July 5, 1938	14.7	59.8	0.3	0.6	2, Tough, Garlicky	Natural	84	21
Do	286	188	Jan. 5, 1939	14.9	58.7		4.0	2, Tough, Light garlicky	Fumigant	16	31
Do	286	335	June 1, 1939	15.0	58.3	.5	14.4	5, Tough, Light garlicky	Natural	9	35
Do	286	370	July 6, 1939	15.1	57.4	.4	18.0	Sample, Tough Light garlicky	Musty	8	38

BIN U-4—UNVENTILATED CHECK BIN FOR BINS U-2 AND U-3 ABOVE, 1938

Average	296	4	July 5, 1938	14.7	59.9	0.3		2, Tough, Light garlicky	Natural	87	20
Inferior [6]	67	73	Sept. 12, 1938	15.0	57.7	.5	10.0	Sample, Tough, Light garlicky, Weevily	Musty	46	32
Balance [7]	229	73	do	14.6	59.5			2, Tough, Light garlicky, Weevily	Natural	77	20

BIN U-5—FORCE VENTILATED WITH NORMAL AIR, 1938

Average	304	0	July 9, 1938	14.5	59.6	0.3	(8)	2, Tough, Garlicky [9]	Natural	81	19
Do [4]	304	82	Sept. 30, 1938	13.8	59.8		(8)	2, Light garlicky, Weevily [9]	Weevily	68	20

[1] All wheat of class Soft Red Winter and subclass Red Winter except where noted.
[2] This is amount of wheat stored in both ends of bin.
[3] Fat acidity calculated from acid value determination and average oil content of soft red winter wheat.
[4] Experiment discontinued because bins were needed for other tests.
[5] Trace.
[6] Sample from north central part of bin, representing about 67 bushels of heating wheat.
[7] Sample from balance of bin, including no wheat from heating or inferior portion.
[8] Negligible.
[9] Mixed wheat of 60 percent hard red winter and 40 percent soft red winter.

Normal outside air was forced into the air chamber of bin U–5 and up through the wheat, for 3 hours on each of 7 days. The average air temperature was 107° F. Moisture tests of average samples of the wheat indicated a total loss in moisture content of 0.6 percent. There was a drop of 0.5 pound in the test weight of the wheat between July 4 and September 29 as shown in table 20. Samples taken from various locations for moisture determinations showed considerable decreases in the moisture content of the wheat in the lower part of the bin, but there was an increase in moisture content of the wheat in the upper part of the bin during the first few days of ventilation.

Bin U–6 was also ventilated for a period of 21 hours, or 3 hours per day for 7 days. The air was heated to an average temperature of 145° F. but at times was much hotter. The total loss in moisture content was 1.2 percent. In this case there was a loss of 1.0 pound in the test weight of the wheat. As in bin U–5, the moisture content of the wheat near the top of the bin increased during the first part of the ventilating period.

The temperature of the wheat 7 inches above the floor of bin U–6, before ventilation with hot air was started, averaged 86° F. The temperature at this level during the ventilation period ranged from 118° to 198°, but with increases of only a few degrees in the wheat temperature at the 3-foot and 5-foot levels. After ventilation with hot air was stopped on July 13, it became necessary to blow normal-temperature air through the wheat in order to lower the temperatures near the floor.

The wheat in bins U–5 and U–6 was removed on June 15, 1937, at which time the moisture content had increased to 14.7 percent in both bins. The grade, germination, and fat-acidity data of average samples drawn from these two bins are shown in table 20, along with similar data for bins U–3 and U–4.

1937 TESTS

The 1936 investigations indicated that although the rate of drying obtained with horizontal flues was very slow, benefit was derived from the dissipation of heat. Because of the possibility that the heating wheat in the unventilated ends of bins U–3 and U–4 in 1936 may have affected the wheat temperature in the ventilated ends, the bins were remodeled in 1937 to provide ventilation of the entire mass of wheat. Ten horizontal flues, running north and south, were installed in bin U–3 in 2 layers of 5 flues each, placed 2 and 4 feet, respectively, above the floor. Each flue in the upper layer was directly over the one below it, and the horizontal distance from the end walls to the flues, and between flues, was 1½ feet. One end of each flue was closed, alternate flues being open on the north and south. Bin U–8, another of the 300-bushel portable bins, was equipped with 30 flues, arranged in 6 layers of 5 flues each, with horizontal distances the same as in U–3. The vertical distance between the floor and the bottom layer and between each 2 layers was 1 foot. As in U–3, one end of each flue was closed, alternate north and south ends being open.

Bins U–3 and U–8 were filled on July 11 with soft red winter wheat, 284 bushels being placed in U–3 and 305 bushels in U–8. The wheat was well mixed but had a moisture content of about 17 percent which was higher than desired for the test. The average temperature of the

wheat in both bins when filled was about 89° F. The temperature rose in the center of bin U–3 to a maximum of 100° on July 26. After 25 days of storage, the wheat turned musty and the bin was emptied on August 5. The temperature in U–8 dropped to approximately 80° in 10 days and held at that temperature until, after 40 days in storage, the wheat turned musty and the bin was emptied. (See table 20 for the initial and final grade, fat acidity, and germination data for these two bins.) When emptied, some wheat in both bins stuck to the walls because of mold, but there was no caking around the flues.

Experiments with forced ventilation in 1936 indicated that much of the ventilating air merely transferred moisture in the mass but did not remove it. To determine the effect on moisture transfer within bins of shortening the length of air travel through the wheat when using forced ventilation, in 1937 two bins, U–5 and U–6, were each equipped with perforated metal floors on 2- by 6-inch joists laid on the regular wooden floors, so as to provide an air chamber under the wheat, and each was further equipped with two layers of five horizontal flues each, the sizes and horizontal spacing of these flues being the same as in bins U–3 and U–8, already described. In bin U–5 the lower layer of flues was 2 feet and the upper layer 4 feet above the perforated floor, while in bin U–6 these distances were 1½ feet and 3 feet, respectively. Through suitably connected header boxes, air could be forced into the wheat by way of the perforated floor and the upper layers of flues and escape through the lower flues and the upper wheat surface.

Both bins were filled on July 16, 1937 to a depth of 5 feet 6 inches with damp wheat which had been used previously for a few days in experiments with insecticides. Simultaneous ventilation of the two bins with normal-temperature air was started on July 20 and continued intermittently through September 15. Both bins had the same depth of wheat, but the upper layer of flues in U–5 was 18 inches below the wheat surface and in U–6 over 24 inches, so there was not an equal distance of air travel within each bin, and more air went through some areas than through others. This was apparent soon after ventilation started, from the differences in the drying rates in the various levels.

Bin U–5 received an average of 620 cubic feet of air per minute. In the total ventilating period of 107 hours, the average moisture content was reduced from 16.4 percent to 13.6 percent. An average of 747 cubic feet per minute was forced into and through the wheat in bin U–6, reducing the average moisture content from 16.1 to 12.5 percent. The moisture content of the wheat having been lowered to a safe moisture content for storage, the purpose of the investigation was accomplished and the bins were emptied on September 23. The initial and final grade, fat acidity, and germination data are given in table 20.

1938 TESTS

In 1938 two of the 300-bushel bins were fitted with vertical flues to test this type of natural ventilation. Although flues of this type had proved very inefficient for drying wheat in previous tests in Kansas and North Dakota, it was thought that under Illinois weather conditions, where the usefulness of ventilation was more apparent in cooling than in drying the grain, they might have some advantages. It is also usually easier to fill and empty a bin fitted with vertical than with horizontal flues. Bin U–2, with tight wood walls and floor, was

fitted with three vertical galvanized flues, 8 inches in diameter, set on the east and west, or long axis of the bin, so that each flue was approximately in the center of mass of a third of the bin (fig. 25). The flues were perforated with small holes from 6 inches above the floor up to about 12 inches below the upper wheat surface. The tops of all three flues were connected by means of 8-inch circular ducts to a com-

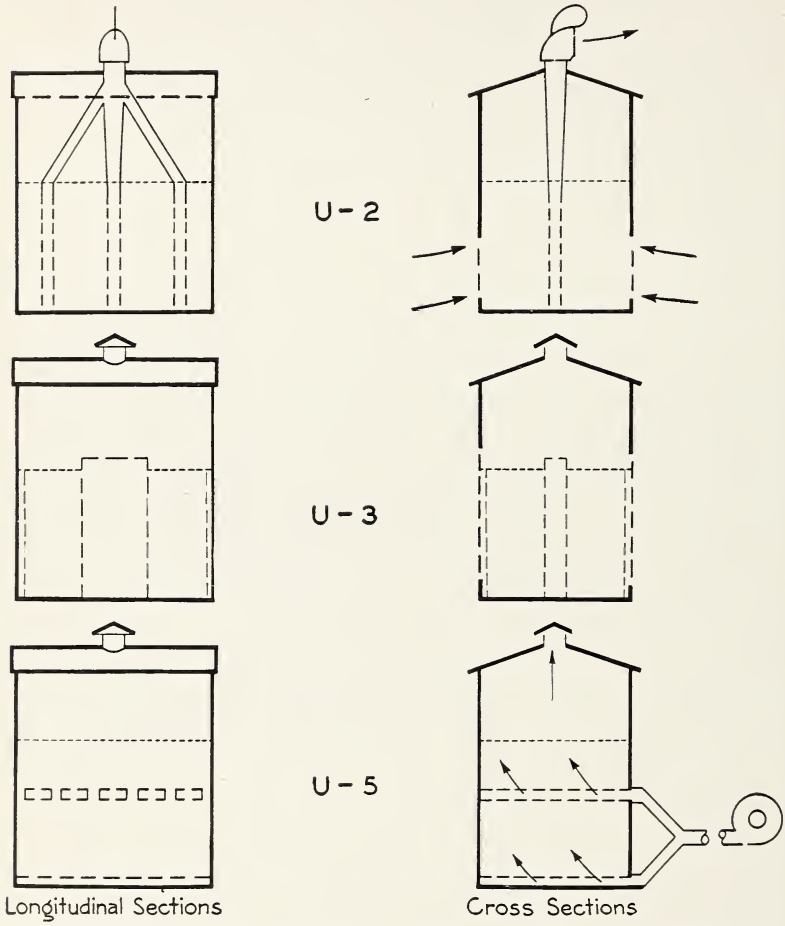

FIGURE 25.—Diagram of ventilated bins used at Urbana, in 1938.

mon suction cowl on the bin roof. Directly opposite the vertical flues three rectangular openings, each 10 inches wide and 45 inches high, were made in the north and south walls, and covered with fly screen backed up by hardware cloth. These wall openings provided inlets for air which could pass out through the vertical flues and suction cowl.

Another bin, U–3, was lined on the inside of the studs with hardware cloth and fly screen, instead of the matched lumber as used in the other bins. In the center of the bin a vertical flue, 8 inches wide

and 32 inches long, of fly screen on a wooden frame was installed, extending from the floor to several inches above the grain line. No suction or pressure cowls were used to assist the flow of air. The flue did not extend through the floor.

Bins U–2 and U–3, with an unventilated bin, U–4, for check purposes, were each filled on July 1, 1938, with 14.7-percent-moisture-content wheat from the same lot; U–2 receiving 294 bushels, U–3, 286 bushels, and U–4, 296 bushels.

The mean temperature of the wheat in all three bins at the time of filling was about 81° F. In U–4, the unventilated bin, there was very little change in temperature until August 1, when the wheat in the north half of the bin, which originally had a moisture content about 0.25 percent above the bin average, started to increase in temperature until on September 12, after being in storage 73 days, a high of 105° was reached, the wheat turned sour, the bin was emptied, and the wheat disposed of. On the other hand, the wheat in bin U–2 dropped within a week to approximately 77°, and except for slight increases during short warm spells, kept this temperature until cold weather arrived. Bin U–3 did not cool as rapidly as U–2, and on August 1, 1938, when the mean temperature of the wheat was 76°, began to increase very slowly in temperature, although never exceeding a peak of 85° reached on August 12 near the bottom of the bin on the north side.

As shown in table 20, there was no drying of the wheat in either U–2 or U–3, perhaps because of the unfavorable drying conditions that are characteristic of this area. Moisture determinations on samples taken from near the screened walls and the flues over a period of several months, indicated that even in those locations very little moisture was removed.

The wheat in bin U–3, without the suction cowl, developed a musty odor sometime between June 1 and July 6, 1939, after about 350 days of storage (table 20). However, the quality of the wheat decreased to a dangerous point even in the first 6 months of storage, the fat acidity being 31.4 units, the germination 16 percent, and the total damage 4 percent, on January 5, 1939. When U–3 was emptied, on August 1, 1939, shortly after turning musty, no caked or rotten wheat was observed in any part of the bin.

The grain in bin U–2 was in storage a considerably longer time before going out of condition, an abnormal odor not being observed until the sampling of July 2, 1940, after 731 days of storage. However, when the bin was emptied about a month later, a small amount of rotten and spoiled wheat was found on the floor near the north wall, and next to the southwest wall screen.

In 1938 a 20-bushel ventilated bin, U–29, was constructed, with wood floors and roof, and perforated metal floor. Further ventilation was provided by six screen-covered horizontal flues spaced so as to ventilate each part of the mass to about the same extent. The bin was 40 inches square to the outside of the studs and 44 inches high. Wheat with 14.7 percent initial moisture content was stored without development of abnormal odor from July 1, 1938, until September 20, 1941, the latest sampling date. Further grade data are given in table 41 of the appendix.

It will be remembered that in the 1936 tests, power ventilation with air introduced at the floor and forced through the entire depth of

wheat, accomplished some drying, although the principal effect was to move moisture from the lower to the upper part of the wheat mass. In 1937 the forced-ventilation bin was modified by the addition of two layers of flues in such a way as to increase the wheat surface exposed to air and to decrease the distance of air travel. However, although the amount of moisture removed per cubic foot of air was increased slightly, the system had the disadvantage of being hard to install because of the many flues.

In 1938, to simplify the bin construction, bin U–5, with tight wood walls and perforated metal floor, was fitted with a single layer of flues with centers 40 inches above the floor. These flues, unlike those used in previous years, were each 18 inches wide and 3 inches thick, covered top and bottom with fly screening. Eighty percent of the bin horizontal cross section was exposed to air. The air entered the wheat both through the floor and the flues, all of it escaping through the upper wheat surface. By adjusting the pressure at the floor and flue inlets, the air entering at the floor could be made to pass up, gathering moisture as it rose, and, at the flues, before it had become saturated, be diluted and lowered in relative humidity by fresh air.

Bin U–5 was filled on July 9 with 304 bushels of mixed wheat (hard red winter 60 percent, soft red winter 40 percent), moisture content 14.5 percent, to a depth of 6 feet 3 inches. On July 14 the blower was started, forcing approximately 700 cubic feet per minute through the floor and 400 cubic feet per minute through the flues, and was run continuously for 31 hours. Only normal-temperature air was used. A series of samples for moisture determination, taken from both above and below the flues, showed that more moisture was removed from above the flues than from below. When ventilation was stopped, although the average bin moisture content had been reduced from 14.4 percent to 13.9, there still were several points below the flues that had over 14 percent of moisture. Complete grade factor data for the wheat at various times during the storage period is given in table 20.

RESULTS OF ILLINOIS VENTILATION TESTS

The weather during the tests at Urbana was more nearly normal than at the other stations and it is probable that the results observed in the ventilation investigations would apply in most years. In figure 26 the average monthly air temperatures and relative humidities for the period July 1936 until December 1940 are given for Springfield, Ill., the nearest United States Weather Bureau station to Urbana.

The horizontal flues tested in bins U–3 and U–4 in 1936 and U–3 and U–8 in 1937 retarded heating but did not remove moisture rapidly enough to avoid eventual damage to wheat containing 15.5 percent or more of moisture. Means must be provided for tightly closing these flues when the bins are fumigated to destroy insects.

The vertical flue used in combination with ventilated walls in bin U–3 in 1938 permitted the escape of some heat, but removed little moisture. It is doubtful if this arrangement is as efficient as horizontal flues in either drying or cooling the wheat. Bin U–2, with screened wall panels and vertical flues spaced about 3 feet on centers and connected to a suction cowl removed little moisture but provided enough air movement through the wheat to prevent rise in tempera-

ture. This arrangement with suction cowls appears to be somewhat more efficient than similarly spaced horizontal flues not connected to cowls, and was successful in storing safely wheat with a moisture content of 14.7 percent for a period 10 times longer than similar wheat was stored in an unventilated bin. Ventilated walls have the disadvantage of making it difficult to close the bin tightly for effective fumigation to destroy insects.

Forcing air up from the bottom of the bin through 6 or more feet of wheat as in bins U–5 and U–6 in 1936 was of small value, for little moisture was removed from the bin and upper layers of the wheat were made excessively damp by condensation of the moisture driven

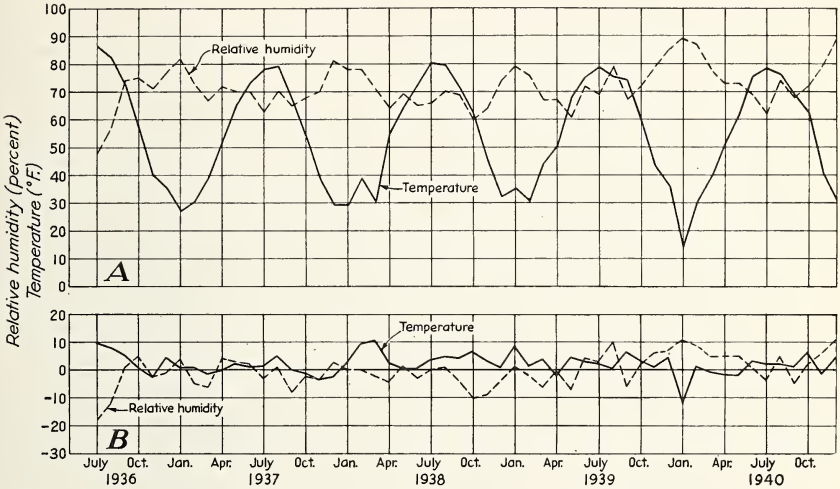

FIGURE 26.—Average monthly air temperature and relative humidity (*A*), and their variation from the normal (*B*), for Springfield, Ill., for the period July 1936, to December 1940.

out of the lower layers. This was true with both unheated and heated air, even under unusually favorable conditions of relative humidity for Illinois.

SURVEYS OF BINS ON FARMS

Surveys of farm-stored wheat were made in 1936, 1937, and 1939, in several States, to observe the storage practices followed in the various wheat-growing regions and to collect data on wheat quality changes while in farm storage. The following discussion of the surveys is arranged according to the year in which they were made.

1936 SURVEYS

In 1936 at each station where experimental bins were constructed, a series of farm cooperator's bins were equipped with thermocouples and the wheat sampled when the bin was filled, or as soon thereafter as possible. A survey of bins was also made in Ohio and Michigan.[10] The initial condition of the wheat for each State, the average number of days the wheat was observed, the average quantity and depth of

[10] The survey in Ohio and Michigan was conducted by J. R. McCalmont and A. H. Glaves of the Bureau of Agricultural Chemistry and Engineering, and H. F. Prue of the Agricultural Marketing Service.

wheat, and the average initial wheat temperature, are given in the summary table 21. For a description of each bin and the kind and quantity of wheat stored in it, see table 42 of the appendix. The counties of Traill and Cass were included in the North Dakota survey; Norman and Polk in Minnesota; Sedgwick in Kansas; Wood and Lucas in Ohio; Lenawee and Washtenaw in Michigan; Washington in Maryland, and Madison, St. Clair, Washington, Christian, Macoupin, and Champaign in Illinois.

TABLE 21.—*Summary of bin size, depth of wheat in bin, and quality of wheat when stored as observed in farm surveys of 1936 and 1937*

State	Bins in survey	Average quantity stored	Average depth of wheat in bin	Average storage period [1]	Portion of bins in which wheat was combined	Wheat moisture content			Average test weight	Average dockage	Average total damage	Average initial wheat temperature
						Average	Maximum	Minimum				
	No.	*Bu.*	*Ft.*	*Days*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Lb.*	*Pct.*	*Pct.*	*° F.*
1936 SURVEY												
North Dakota	15	631	6.3	90	60	9.5	11.5	7.2	55.4	1.7	0.03	87
Minnesota	15	766	8	93	7	8.4	9.5	7.7	54.8	1.6	.09	84
Kansas	25	742	7.2	129	96	9.8	12.4	8.1	60.6	.5	.2	95
Illinois	27	530	4.8	102	26	10.7	14.0	9.2	60.0	.5	.2	98
Ohio	16	392	5.5	145	56	11.3	14.9	9.5	58.5	1.5	.4	89
Michigan	10	253	5.0	117	10	10.8	12.4	10.2	59.0	.4	.7	84
Maryland	18	410	4.6	89	0	12.6	16.4	10.7	57.5	1.2	2.1	83
1937 SURVEY												
Illinois	11	183	3.5	51	73	14.8	15.7	14.4	51.0	0.6	0.5	80
Ohio	13	299	5.0	84	23	13.1	14.2	11.4	53.4	.2	3.8	81
Michigan	13	341	4.4	81	8	14.4	16.0	12.8	51.9	.8	17.2	83
Maryland	12	490	3.9	112	0	14.4	15.3	13.7	57.5	1	3.5	80

[1] Period during which observations were made on stored wheat.

Because of the dry weather during the harvest and threshing season most of the wheat went into farm storage at a low moisture content. Of the 126 bins in the different surveys the wheat in only one bin, T–58 in Wood County of Ohio, turned sour. Examination showed that a portion of the wheat had a moisture content of 16.3 percent, as compared to 14.9 percent for the bin average. The wheat in bin U–75, Champaign County, Ill., also started to heat, but was moved and mixed before the entire lot went out of condition. The heating portion of wheat in this bin had a moisture content of 17.5 percent, compared to the bin average of 11.6 percent.

Observations were continued on the wheat in the farm bins until the cooperators sold their grain or until cold weather.

Study of table 21 shows that in general the bins were larger in the more western areas, and that the wheat was also stored to a greater depth. The lowest moisture content wheat also occurred in the western area (North Dakota, Minnesota, and Kansas) while the highest moisture content wheat was found in Maryland. The initial wheat temperature in Kansas and Illinois averaged 10° F. higher than in the other States.

1937 Surveys

Arrangements were made in 1937 to repeat the farm surveys of 1936, but dry weather again occurring during the harvest and threshing season, resulting in very dry wheat, no observations were made on farm stored wheat in North Dakota, Minnesota, Kansas, or Michigan. In Ohio, Illinois, and Maryland, however, the wheat in 49 farm bins was sampled and temperature readings made. These observations are summarized by States in table 21, and given for each bin in table 43 of the appendix. Although the wheat moisture content ran considerably higher than in 1936, the wheat in only one bin in Maryland, B–50, one bin in Illinois, U–92, and 6 bins in Michigan, T–70–A, T–70–B, T–71–A, T–74–A, T–74–B, and T–88, turned sour or musty while under observation. The average moisture content of all these bins was over 14.5 percent; however, the periods of observation were very short.

1939 Surveys

In 1938 no farm bins were inspected and sampled. In 1939 two surveys, one in Kansas and one in the soft red winter wheat area of Indiana, Ohio and Michigan, were made.

In the Kansas [11] survey samples were obtained from 47 bins located in Sedgwick, Sumner, Pratt, Riley, and Franklin counties, during July, shortly after harvest. At that time the average moisture content of the wheat in the bins ranged from 9.7 to 17.3 percent. In the latter part of September, about 2 months later, 22 of the bins in the vicinity of Wichita, the section where most of the high moisture content wheat was found, were revisited and sampled. The grade data for all samples, and a brief description of each bin, are given in table 44 of the appendix.

The wheat in 17 of the 47 bins was above 13 percent moisture content when sampled the first time. At the second sampling, as shown by appendix table 44, most of the wheat above 13 percent moisture content had turned sour or musty, the exceptions being where the wheat had been turned several times, or had heated in only a small portion of the bin.

The 1939 survey in the soft red winter wheat belt was made on wheat stored under the loan program in 139 bins in Michigan, Ohio, and Indiana.[12] Samples were secured from 126 storages of the 1938 crop, 12 storages of the 1937 crop, and 1 storage of the 1936 crop. The grade data of the wheat, and a brief description of each bin are given in table 45 of the appendix. Of the bins of 1938 wheat, 117 of the 126 bins had a moisture content over 13 percent. Forty-six of the bins had a wheat moisture content over 14 percent. However, the wheat in only 2 bins (S–84 and S–103) had a musty odor when sampled after 10 months in storage.

The wheat of the 1937 crop, stored in 12 bins, all had over 13.3 percent moisture content when sampled, after about 670 days in storage. The wheat in 5 of these bins had an abnormal odor at that time.

[11] Survey of farm bins in Kansas conducted in 1939 by W. R. Swanson, junior agricultural engineer, Bureau of Agricultural Chemistry and Engineering.

[12] Survey of farm bins in soft red winter wheat belt conducted in 1939 by B. M. Stahl, associate agricultural engineer, and Thayer Cleaver, assistant agricultural engineer, Bureau of Agricultural Chemistry and Engineering.

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UNDERGROUND STORAGE OF WHEAT

The storage of wheat underground, in order to take advantage of the lower ground temperatures during the summer months, was investigated at Hays, and on a much smaller scale at Urbana. This practice is followed quite extensively in the Island of Malta, apparently very successfully. The Malta bins are usually about 15 feet in diameter and 25 feet deep, and are kept in as airtight a condition as possible in order to hinder insect activity. Before the grain is stored the bin walls and bottom are covered with a layer of straw, to protect the grain from dampness. Investigations have also been made in South Australia to determine the effectiveness of underground storage for insect control (*6*).

In 1937 one 100-bushel bin and five 20-bushel underground bins were constructed and filled at Hays. The 100-bushel bin, H–9, was a circular hole 6 feet deep and 6 feet in diameter. Although the ground water level is normally very low, the site of the bin was not well drained of surface water. The floor was of cement plaster and flat. The walls were covered with cement plaster, reinforced with chicken wire, to a height of 4½ feet above the floor. A conical top of common brick was built over the underground bin, sloping 9 inches per foot and extending from the plastered wall to a circular manhole 2 feet in diameter. The upper part of the conical top was 6 inches above the ground level and was covered with a removable concrete slab. The bin was filled on July 1, 1937, with 92 bushels of wheat having a uniform moisture content of 13.0 percent. The quality of the wheat at this time, as well as at subsequent sampling dates, is given in table 22. The temperature of the wheat, averaging about 94° F. when placed in the bin, lowered in 2 weeks to 83° in the center of the bin, and to below 70° near the bin bottom. However, at noon the wheat temperature at the upper wheat surface sometimes went above 100° F. because of solar heat transmitted through the concrete manhole cover. There was also indication of heating near the north wall during the first 2 weeks of storage, temperatures as high as 117° F. being observed.

On March 11, 1938, 254 days after being stored, samples were taken from different locations in the bin to determine the condition of the wheat. The grade data from these samples are given in table 23. It can be seen that the moisture content in the upper part of the bin had increased from 1 to 3 percent over the original, and that the wheat quality had also lowered to the greatest extent in that area. There is also evidence that the moisture content of the wheat near the walls was higher than in the center of the bin, and that this moisture increase was accompanied by lower wheat quality. It is possible that the high moisture content (16.0 percent) of the sample taken 18 inches from the wall in the upper third of the bin was due to rain leaking in around the manhole cover. The sampler observed a ring of spoiled and badly molded wheat, about 2 inches thick, extending around the bin against the outside wall. This spoiled wheat was removed on March 11 when the bin was sampled. The bin was sampled again on June 20, 1938 (after 355 days in storage) and the wheat was found to be musty throughout. Later, on August 15, 1938,

the upper third of the bin was still much higher in moisture content than when stored, but there was very little moisture change in the lower part of the bin. Grade data from all samples are shown in table 22.

TABLE 22.—*Grade data, quantity stored, days in storage, percent germination, and fat acidity of wheat stored in underground bins at Hays*

Sample type	Quantity	Time of storage	Date sampled	Wheat moisture content	Test weight per bushel	Dockage	Damage	Grade [1]	Odor	Germination	Fat acidity
	Bu.	*Days*		*Pct.*	*Lb.*	*Pct.*	*Pct.*			*Pct.*	*Units*
BIN H-9 (1937)											
Average	92	1	July 1, 1937	13.0	62.1	0.5	0.5	1	Natural	90	10
Do	92	76	Sept. 14, 1937	13.2	61.0		.6	1	do	80	15
Do	92	182	Dec. 29, 1937	11.1	60.1		2.9	2	do	74	17
Do [2]	92	254	Mar. 11, 1938	13.6	60.4		.9	1	do	75	18
Do [3]	92	355	June 20, 1938		60.8	.4		Sample	Musty		
Top [4]	31	411	Aug. 15, 1938	15.1	59.4	.3		do	do	20	31
Middle [4]	31	411	do	12.9	61.2	.3	(5)	do	Slightly sour.	49	18
Bottom [4]	30	411	do	12.9	60.4	.3	(5)	do	Musty	52	17
Average	92	762	Aug. 1, 1939	14.0	60.0	.4	7.0	do	Sour	30	24
BIN H-41 (1938)											
Average	1,004	2	July 8, 1938	10.3	55.0	0.3	0	4	Natural	81	12
Do	1,004	26	Aug. 1, 1938	11.4	54.8	.3	.0	4	do	81	15
Do	1,004	185	Jan. 7, 1939	10.4	54.0	.4	.0	4	do		
Do [6]	1,004	213	Feb. 4, 1939	11.0	54.3	.3	.0	Sample	Musty	79	17
Do	1,004	344	June 15, 1939	12.0	54.0	.3	(5)	do	do	78	18
BIN H-42 (1938)											
Average	1,022	3	July 1, 1938	13.5	57.2	0.4	0	3	Natural	88	12
Do	1,022	34	Aug. 1, 1938	13.7	56.7	.3	.0	3	do	84	17
Do	1,022	193	Jan. 7, 1939	13.5	56.3	.3		3	do		
Do [6]	1,022	221	Feb. 4, 1939	13.8	56.6	.4	.8	Sample	Musty	60	23
Do	1,022	252	Mar. 7, 1939	13.8	56.8	.3		do	do	47	23
BIN H-41 (1939) VENTILATED BY PRESSURE COWL											
Average	1,000	2	June 30, 1939	13.0	60.2	0.2	0	1 [7]	Natural	93	13
Do	1,000	64	Aug. 31, 1939	12.4	59.5	.2		2 [7]	do	91	15
Do	1,000	215	Jan. 29, 1940	12.1	59.5	.3		2 [7]	do	94	16
Do	1,000	403	Aug. 5, 1940	12.7	59.6	.2		2 [7]	do	87	
Do	1,000	560	Dec. 30, 1940	12.8	59.4	.2	(5)	2 [7]	do	88	
Do	1,000		Mar. 3, 1941	13.1	58.2	.5	(5)	Sample [7]	Musty (rodent).	88	

[1] All wheat of class Hard Red Winter and subclass Dark Hard Winter except where noted.
[2] Average of 15 samples taken from various locations in bin.
[3] Average of 3 samples taken from top, middle, and bottom portions of bin.
[4] Samples are average for top, middle, and bottom thirds of bin.
[5] Trace.
[6] First sample showing abnormal odor.
[7] Wheat of class Hard Red Winter and subclass Hard Winter.

Samples for milling and baking tests were obtained from bin H-9 periodically until August 3, 1939. In all cases the bread had a natural taste and odor, indicating that the sour odor of the wheat was only present on the surface of the kernels. The low fat acidity determinations also show that the wheat had not deteriorated materially.

TABLE 23.—*Grade data for samples removed from underground bin H–9 at Hays, on Mar. 11, 1938*

Distance from wall (inches)	Wheat moisture content	Test weight per bushel	Total damage	Grade [1]	Odor	Germination	Fat acidity
	Percent	*Pounds*	*Percent*			*Percent*	*Units*
UPPER THIRD OF BIN							
0	15.0	59.8	0.6	2, Tough	Natural	62	29
6	15.3	60.8	.4	1, Tough	do	51	29
12	14.2	60.6	.3	1, Tough	do	68	21
18	16.0	58.0	6.0	Sample	Musty	36	30
36 [2]	13.9	59.6	.7	2	Natural	66	18
MIDDLE THIRD OF BIN							
0	13.2	60.4	0.7	1	Natural	86	14
6	13.3	60.0	.9	1	do	83	15
12	12.5	61.3	.4	1	do	86	12
18	12.7	60.1	.6	1	do	80	15
36 [2]	12.6	60.0	1.0	1	do	81	14
BOTTOM THIRD OF BIN							
0	13.3	61.1	0.5	1	Natural	84	16
6	13.4	61.1	.3	1	do	85	14
12	13.3	60.8	.5	1	do	86	13
18	12.7	61.1	.4	1	do	85	13

[1] All wheat of class Hard Red Winter and subclass Dark Hard Winter.
[2] At center of bin.

The five 20-bushel underground bins, H–20, H–21, H–22, H–23, and H–24, filled in 1937 were merely metal containers 40 inches in diameter and 36 inches high, fitted with conical metal roofs. The joint between the roof and walls was sealed with asphalt. A 4-inch-diameter metal pipe 3 feet long was soldered to the peak of the conical roof so that it extended out of the ground and could be used for filling and sampling the bins. The containers were buried deep enough to bring the peaks of the conical tops 2 feet below the ground level. The bins were arranged in three groups according to the moisture content of the stored wheat. For each group a plain metal above-ground bin of the same size and filled with the same moisture content wheat was used as a check. Thus, above-ground bin H–25 and underground bins H–20 and H–23 were filled with wheat of approximately 13.0 percent moisture content, check bin H–26, and buried bins H–21 and H–24 with wheat of about 15.0 percent moisture content, and check bin H–27 and underground bin H–22 with wheat of 15.5 percent moisture content. Samples for grade inspection and germination and fat acidity determinations were taken at intervals until an abnormal odor developed in each bin; the results are given in table 24.

These data show that at the lower moisture content, 13.0 percent, there was little difference between the above-ground and underground bins insofar as the length of time that elapsed before development of abnormal odors was concerned. However, as there were no samples drawn between March 11, 1938, when all the wheat of 13 percent moisture content had a natural odor and August 15, when all the wheat was sour, it is possible that some of the wheat went out of condition several months before the remainder. The germination and

TABLE 24.—*Comparison of wheat moisture content, average temperature, odor, germination, fat acidity, and days stored before going out of condition, for wheat of different initial moisture contents in small plain metal and underground bins at Hays, 1937* [1]

WHEAT CONTAINING 13 PERCENT MOISTURE

Date	Time in storage	Wheat moisture content			Average wheat temperature			Wheat odor			Germination			Fat acidity		
		H-25	H-20	H-23	H-25	H-20	H-23	H-25	H-20	H-23	H-25	H-20	H-23	H-25	H-20	H-23
	Days	*Percent*	*Percent*	*Percent*	*° F.*	*° F.*	*° F.*				*Percent*	*Percent*	*Percent*	*Units*	*Units*	*Units*
July 8, 1937	1	12.9	13.1	13.2	94	87	89	Natural	Natural	Natural	80	80	78	18	22	19
Aug. 10, 1937	34	13.0	13.1		90	72	72	do	do		72	76		22	19	
Sept. 14, 1937 [2]	69	12.9	13.2		72	70	70	do	do		70	74		23	21	
Dec. 29, 1937	175	12.9	13.4	13.3				do	do	Natural	62	70	79	24	22	23
Mar. 11, 1938	247	13.0	14.8	13.5.				do	do	do	66	59	67	23	24	23
Aug. 15, 1938	404	12.9	14.0	13.3				Sour	Sour	Sour	62	32	39	24	28	29

WHEAT CONTAINING 15 PERCENT MOISTURE

		H-26	H-21	H-24	H-26	H-21	H-24	H-26	H-21	H-24	H-26	H-21	H-24	H-26	H-21	H-24
July 2, 1937	2	14.7	15.0	15.0	84	81	80	Natural	Natural	Natural	76	80	82	17	18	18
Aug. 10, 1937	41	14.5	14.5		95	82	74	do	do		36	68		27	20	
Sept. 14, 1937 [2]	76	14.0	14.5		79	70	70	Musty	do		23	52		38	22	
Dec. 29, 1937	182		15.1	15.1					Slightly sour	Sour		24	0		24	28

WHEAT CONTAINING 15.5 PERCENT MOISTURE

		H-27	H-22		H-27	H-22		H-27	H-22		H-27	H-22		H-27	H-22	
July 2, 1937	2	15.4	15.6		85	81		Natural	Natural		70	64		20	22	
July 20, 1937	20	14.7	15.7		94	75		Musty	do		18	46		37	24	
Aug. 10, 1937	41		15.8			76			Slightly musty			19			32	

[1] Bins H-25, H-26, and H-27 were metal above ground, and bins H-20, H-21, H-22, H-23, and H-24 underground.
[2] Temperature observations were made on Sept. 11, 1937.

fat-acidity determinations indicate that this might have occurred as the wheat stored underground showed a much greater deterioration in quality, as measured by these two indices, than did the wheat stored above ground in bin H–25. This was probably caused by the increase in wheat moisture content in the underground bins H–20 and H–23.

At the higher wheat moisture contents, 15.0 and 15.5 percent, the rate of deterioration was less in the underground bins, as indicated by odor, loss in germination, and increase in fat acidity. In the 76 days of storage in which the wheat in the above-ground bin, H–26, developed an abnormal odor, the decrease in germination was 25 percent more and the increase in fat acidity 17 units more in the conventional bin, H–26, than in the underground bin, H–21. Differences observed with the 15.5 percent wheat stored in bins H–27 and H–22 were very similar.

Three small underground bins, U–26, U–27, and U–28, were also filled at Urbana in 1937. These bins were smaller than the Hays bins, being metal containers 2 feet in diameter and 3 feet deep, with a conical top, and being of heavier material with all joints soldered, they were probably more nearly watertight. The capacity of each bin was 6 bushels. Wheat with a moisture content of approximately 12.7 percent was placed in bin U–26 and in an above-ground 20-bushel metal check bin U–11, and wheat with about 14.5 percent moisture content in underground bins U–27 and U–28, and in above-ground check bin, U–13. Immediately after filling the oxygen was reduced in bin U–28 by burning a candle above the wheat. A sheet-metal cover was then placed over the top and sealed with tar. An analysis of the gases in the underground bins in January 1938 showed that the tar seal was not entirely effective in preventing the entrance of more oxygen into the bin. The other two bins, U–26 and U–27, were not sealed but the pipes extending above ground were merely covered with a loose-fitting cap to exclude snow and rain. The condition of the wheat when placed in storage and after 909 days is given for each underground bin and its check bin in table 41 of the appendix. The loss in quality of the wheat was about the same in all wheats of similar initial moisture content insofar as odor, test weight, and fat acidity were concerned, but the germination was reduced to zero in the unsealed underground bins U–26 and U–27 and decreased only slightly in the sealed underground bin U–28 and the above-ground check bin U–11. The germination decrease in bins U–26 and U–27 was very little during the first few months of storage but some time between September 1937, and January 1938, during which period no samples were taken, the germination dropped to almost zero. This may have been caused by the use of chlorasol as a fumigant. It was not necessary to fumigate the sealed bin.

Further studies of underground storages were made at Hays in 1938. Two 1,000-bushel underground bins, H–41 and H–42, were constructed both somewhat similar to 1937 bin H–9, but larger, being 13 feet in diameter and 12 feet deep. The walls and floors were coated ½-inch thick with cement plaster, and the tops covered with 4-inch concrete slabs provided with manholes and sampling holes.

Bin H–41, along with a plain metal 500-bushel above-ground bin, H–2, and a small metal bin, H–29, were filled on July 8 from the same lot of combined wheat averaging 10.3 percent moisture, but varying

from 8.2 percent to 15.0 percent. Quantity stored, grade factor data, germination, and fat acidity determinations from successive samples drawn from H–41 are given in table 22 and the initial and final data for the wheat stored in all the bins in table 42 in the appendix. After the wheat was in storage 1 week it was observed that the top layers in H–41 were hot during the day and as a measure of protection from solar radiation a 6-inch layer of gravel was spread over the concrete slab top. All bins were fumigated with carbon disulfide on July 24, 1938, to prevent insect infestation.

The temperature of the wheat in H–41 decreased very slowly in the mass although the wheat near the wall cooled quickly. At the bin center the temperature was still above 80° F. on October 1.(*4*). On February 4, 1939, after only 213 days in storage, the average sample from the bin had a musty odor and a layer of moldy wheat was found caked to the upper part of the wall in a layer one-half to 1 inch thick. The bin was emptied several months later, on June 16, 1939, at which

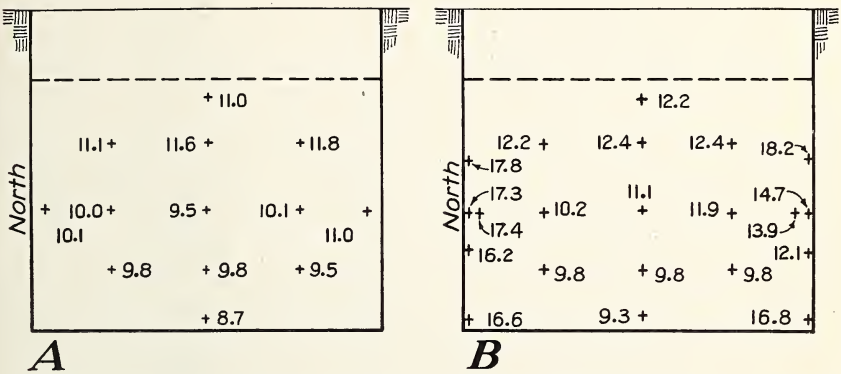

FIGURE 27.—Wheat moisture content in bin H–41 at beginning and end of storage period: *A*, July 8, 1938; *B*, June 15, 1939.

time the caked wheat extended entirely around the upper 5 feet of the bin in a layer about 5 inches thick. However, bread made from an average sample from the bin had a natural taste and odor. Several times during the storage period a series of samples were obtained for moisture, germination, and fat acidity determinations from various locations in the bin. The results of the moisture tests are shown in figure 27 for the first and final samplings, July 8, 1938, and June 15, 1939.

The fact that during this period the moisture content increased several percent near the wall might at first glance be attributed to condensation of moisture from the warm central part of the bin on the cool walls. However, as shown by the figure, none of the wheat decreased in moisture content, and according to the data in table 22 the average wheat moisture content increased from 10.3 to 12.0 percent. A plausible explanation for the increase in moisture at the bin wall, therefore, is that it passed through the cement-plaster lining from the outside soil even though the bin was in a well-drained location. Part of the moisture increase might possibly have been produced by respiration of the wheat kernels in the central warm part of the bins, in which process water and carbon dioxide are released.

As shown by other investigators (*1*, *2*, *7*) the respiration rate is dependent on the wheat moisture content and temperature.

The points in figure 27, *B*, having the highest moisture content also showed the greatest loss in germination and increase in fat acidity. The wheat having 17.8 percent moisture at the north wall near the top of the bin had a germination percentage of 11 and a fat acidity of 33.8 units, compared to a germination percentage of 86 and a fat acidity of 16.5 units for the 11.1 percent wheat at the bin center.

In order to compare the rates of deterioration of the wheat in underground bin H–41 and the two above-ground check bins H–2 and H–29, table 25 was prepared. The length of storage before development of an abnormal odor was much greater in the metal bins. Although bin H–2 was emptied before the wheat went out of condition, the rates of deterioration up to that time, as indicated by percent germination,

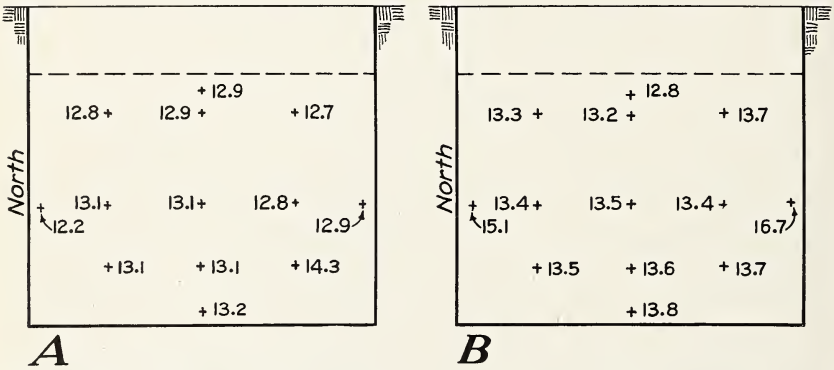

FIGURE 28.—Wheat moisture content in bin H–42 at beginning and end of storage period: *A*, July 2, 1938; *B*, March 7, 1939.

and fat acidity, were greater in the 500-bushel bin H–2 than in the 20-bushel bin, H–29.

The second large underground bin, H–42, tested in 1938, was filled on June 29 with 1,022 bushels of wheat averaging 13.5 percent moisture content quite uniformly distributed through the bin. As with bin H–41, the concrete top was covered with 6 inches of gravel after the first week of storage. The average grade, moisture content, germination, and fat acidity of the wheat at various times during the storage period are given in table 22. The first abnormal odor was detected in the average sample on February 4, 1939, after 221 days of storage, and a layer of moldy caked wheat about 1 inch thick around the upper part of the bin was observed at the same time. The bin was completely sampled on March 7, 1939, and emptied, at which time the wheat moisture content had increased in almost all parts of the bin, the greatest increase being near the wall areas. The moisture content in the various locations at the time the bin was filled and on March 7 are shown in figure 28. The wheat was found to be caked in a layer 6 inches thick on the upper half of the wall. However, as with bin H–41, bread made from an average sample had a natural odor and taste.

TABLE 25.—*Comparison of rates of deterioration, length of safe storage, temperature and moisture content, of wheat stored at Hays in underground bin H–41 and metal bins H–2 and H–29* [1]

Date	Time in storage	Wheat moisture content			Wheat temperature [2]		Odor			Germination			Fat acidity		
		H–41	H–2	H–29	H–41	H–2	H–41	H–2	H–29	H–41	H–2	H–29	H–41	H–2	H–29
	Days	*Pct.*	*Pct.*	*Pct.*	*° F.*	*° F.*				*Pct.*	*Pct.*	*Pct.*	*Units*	*Units*	*Units*
July 8, 1938	2	10.3	10.3	9.4	93	90	Natural	Natural	Natural	81	80	78	12	11	15
Aug. 1, 1938	26	11.4	10.4		86	86	do	do	do	81	81		15	16	
Jan. 7, 1939	185	10.4	9.7		60	39	do	do	do						
Feb. 4, 1939	213	11.0	9.6	9.6	58	37	Musty	do	do	79	84	84	17	15	14
Aug. 1, 1939	391		9.9	10.3		83		do			81	87		16	15
Oct. 26, 1939	477		9.8			63		do [3]			92			16	
May 2, 1940	565			10.5					Natural			92			17

[1] Bin H–41 contained 1,004 bushels, H–2 contained 486 bushels, and H–29 contained 21 bushels.
[2] Average temperature for entire bin.
[3] Bin H–2 emptied on Nov. 2, 1939, before developing abnormal odor.

Because the wheat in the large underground bins appeared to be going out of condition principally due to the accumulation of moisture on the walls, series of wall treatments were tested in bin H–42 after the 1938 wheat was removed. The wall surfaces were divided vertically into 10 equal spaces or panels and opposite panels treated as follows: (1) No treatment (concrete surface contacting wheat), (2) straw blanket or mat, (3) aluminum-foil paper, (4) aluminum foil paper over ½-inch insulation board, (5) fly screen supported 3 inches away from wall on furring strips. The 1938 wheat, excluding the caked portions, was placed in a power-ventilated bin and air blown through it to remove as much of the mold and musty odor as possible. The same wheat was then returned to underground bin H–42, having the various wall treatments, on March 25, 1939. The average moisture content was 14.0 percent, average temperature approximately 50° F., odor sour, germination 56 percent, and fat acidity 21.7 units. Samples were taken several times during the summer and following winter from as close as possible to the various wall treatments to observe the changes in wheat moisture content and quality. The results of these tests are summarized in table 26.

TABLE 26.—*Comparison of efficiency of plain concrete wall and four treatments of wall to prevent accumulation of moisture and deterioration of wheat stored in underground bins* [1]

Time stored (days)	Date	Wheat moisture content	Germination	Fat acidity	Condition
UNTREATED WALLS (WHEAT CONTACTING CONCRETE)					
		Percent	*Percent*	*Units*	
76	June 9, 1939	20.5			1 inch of caked wheat.
262	Dec. 12, 1939	18.9			6 inches of caked wheat (some weevils).
340	Feb. 28, 1940	15.6	14	34	Musty.
SCREEN FURRED AWAY FROM CONCRETE WALLS					
76	June 9, 1939	14.2			Good.[2]
262	Dec. 12, 1939	13.8			
340	Feb. 28, 1940	13.6	24	27	
ALUMINUM FOIL PAPER BETWEEN CONCRETE AND WHEAT					
76	June 9, 1939	14.1			Slight dampness.
262	Dec. 12, 1939	14.2			Good.[2]
340	Feb. 28, 1940	14.2	47	27	
ALUMINUM FOIL OVER ½-INCH CELOTEX BETWEEN CONCRETE AND WHEAT					
76	June 9, 1939	13.4			Good.[2]
262	Dec. 12, 1939	14.2			
340	Feb. 28, 1940	14.2	42	24	
STRAW MAT BETWEEN CONCRETE AND WHEAT					
76	June 9, 1939	15.7			Damp and musty.
262	Dec. 12, 1939	15.7			Badly weevil infested.[3]
340	Feb. 28, 1940	15.3	12	36	Musty.

[1] All determinations are the average for the 2 similar panels.
[2] As compared to initial condition.
[3] Bin was fumigated after this sampling.

The plain concrete wall and the straw mats were the least satisfactory of the five treatments tested, both as to moisture accumulation and condition of wheat. There was little difference noticed in the results obtained with the two wall treatments using aluminum foil. The loss in germination and increase in fat acidity was slightly less in the panels of aluminum foil over ½-inch insulation than where the plain aluminum foil was used. However, both gave better results in this respect than any of the other treatments. The fly screen supported 3 inches away from the wall by furring strips dried the wheat slightly near the wall but was not as satisfactory as the foil in maintaining the germination.

In 1939 the old underground bin H–41 was remodeled to provide ventilation for hastening cooling and for preventing the development

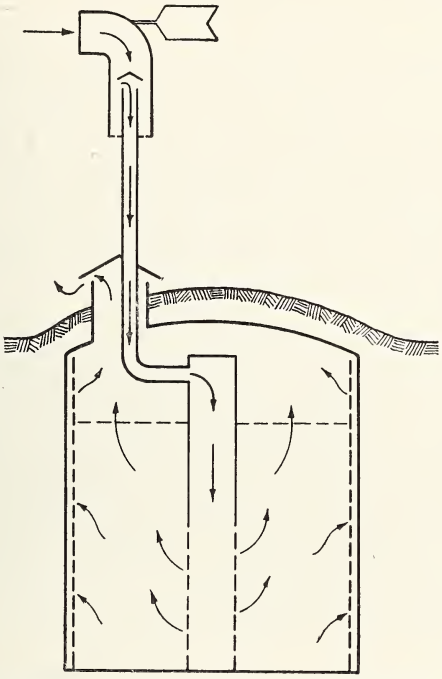

FIGURE 29.—Diagram of underground bin H–41 filled at Hays, in 1939.

of objectionable odors. The bin was lined with 14-mesh fly screen, supported 3 inches away from the walls on 2- by 2-inch studs and 1- by 2-inch horizontal nailing strips. A vertical wooden flue, 18 inches square, with the bottom 6 feet covered with screen, but the top section airtight, was placed vertically in the bin center. A pressure cowl with a vane to keep the cowl headed into the wind was placed on a stand above the bin and connected to the top of the central 18-inch flue by an 8-inch round pipe. The path of the air forced into the cowl was down the 18-inch flue, through the wheat to the bin wall or upper wheat surface, and out through a suitably protected opening in the bin top to the open air (fig. 29).

The bin was filled on June 28, 1939, with 1,000 bushels of new wheat with a moisture content of 13.0 percent. The wheat was well mixed

and the moisture content quite uniform. The initial grain temperature averaged about 84° F. The condition of the wheat when the bin was filled and at successive sampling dates is shown in table 22. The wheat temperature in 3 weeks lowered in all parts of the bin to below 80° and in some points below 65°. The ventilating system was left in operation during the winter but was closed in June 1940, to prevent the hot outside air from raising the wheat temperature.

It was necessary to fumigate February 1, 1940, because weevils were found in the upper layers of the wheat.

No indication of caking, molding, or other deterioration was found at the latest sampling on December 30, 1940.

Summary of Underground-Storage Studies

In an investigation of underground storage at Hays, in which four large and four small bins were filled with wheat, and at Urbana, in which three small bins were tested, it was found that the greatest hazards are accumulation of moisture near the bin walls and the slow cooling of the grain when placed in storage at a temperature higher than that of the ground. When the wheat was cooled quickly, either by ventilation or because of the small mass stored, and when precautions against outside moisture entering the bin were taken, the grain could be stored with less deterioration and for longer periods of time than could wheat of similar average moisture content stored above ground.

A method of treating the plastered walls of underground bins by placing a layer of aluminum foil paper with or without a layer of ½-inch insulation board between the plaster and the wheat was successful in preventing the accumulation of moisture at the bin wall. A layer of straw was unsatisfactory. Fly screen, furred 3 inches away from the plaster wall but with no provision for free air movement, prevented moisture accumulation but apparently resulted in a greater decrease in percent germination of the wheat against the wall. In large masses of wheat having a comparatively high initial temperature, the fly-screen wall treatment, in connection with a central flue receiving air under slight pressure from a cowl above the bin, was very effective in quickly cooling the wheat.

CHANGES IN FAT ACIDITY AND GERMINATION OF WHEAT FROM SELECTED LOCATIONS IN STORED BULKS

It has been shown that the average conditions of storage frequently involve a rather wide range of wheat moisture contents and temperatures within a bin. This made it desirable to secure samples from various locations in the bin where thermocouples were installed. Several thousand samples were thus obtained, after successive periods of storage, and tested for fat acidity and germination according to the procedure used on the average samples. Data for each sample were

entered on punch cards and sorted into groups according to temperatures and moisture contents as explained later (page 110). The data for each sample included sample identification, average moisture content and temperature since previous sample, days storage since previous sampling, and changes in fat acidity and germination since previous samplings.

Temperatures at each thermocouple location were taken daily during the summer months, but less frequently as the weather became colder. This made it possible to estimate quite accurately the trend in temperature changes from one sampling period to the next. However, it was found that an estimate of the average temperature of the wheat at any point in the bin based on temperatures when two successive samples were secured was generally within 5° F. of the average of all intermediate temperatures. A greater error in the estimated average temperature was found in a few instances where the interval between samplings exceeded three or four months and included midsummer or winter reversals in the trend of temperatures. The estimated average moisture content of the wheat based on tests of successive samples was usually within 0.5 percent of the average indicated by the plotted trend value. The approximate conditions given by these estimated averages have been used on the assumption that they are sufficiently accurate measures of the temperature and moisture content of the wheat at a particular location during successive intervals of storage under field conditions.

The changes in fat acidity and germination indicated by tests of samples taken at intervals from the same locations in each bin were used as measures of the effect of storage on wheat having average temperatures and moisture contents as mentioned above. Germination and fat acidity tests on a series of samples from a particular location give results that fluctuate considerably about any apparent trend. An illustration of this variation is given in figure 15, even though it represents tests on average samples. The samples from bin F–8 show a rather uniform and gradual trend in loss of germination although successive pairs of samples, for example, those secured December 2, 1938, and January 2 and February 4, 1939, may indicate rapid decrease or increase in the viability of the wheat. Some of the reasons for these apparent reversals in test results are discussed below.

In securing, handling, and testing such a large number of samples an occasional error could be expected because of incorrect identification of a sample, damage during shipment, or other unavoidable conditions that would give misleading or erratic results. Test data from some crops or storages were found to be much more variable than others. As a guide to assist in distinguishing normal and abnormal variations in the data typical bins at each field station in which a particular crop of wheat was stored were selected, and all of the germination and fat acidity data from each of ten locations in these bins were plotted and the standard error determined. If the germination or fat acidity of a sample from a similar type of bin containing wheat of the same crop differed from that of the preceding sample more than twice this standard error, the data for all other samples from the same location were plotted so that the apparent trend could be indicated. Where the test result in question varied from the

apparent trend value by more than twice the standard error, the data on both germination and fat acidity for the sample were discarded unless there was reason to believe that some other factor influenced the results, such as exceptional variations in the temperature or moisture content of the wheat during the interval between samplings. Since the standard error for fat acidity varied from 1.8 to 3.2 units and for germination from 3.6 to 8.3 percent while plotted trends indicated changes of considerably less than these amounts in the interval between sampling dates, except in cases of very high temperature or moisture content, the method of determining rate of change from the difference in successive samples could give consistent results only if a very large number of samples were available.

Records on more than 3,000 samples from large storages were finally used in determining the changes, during various periods of storage, in the fat acidity and germination of wheat having an estimated average temperature and moisture content as previously mentioned. These data were grouped according to the three wheat-producing areas in which the storages were located; that is, Hard Winter Wheat, Soft Winter Wheat, and Spring Wheat. Each of these groups was subdivided on the basis of samples secured from ventilated and unventilated storages during the first year of storage and after the first year. A final subdivision of the data was made on the basis of the average moisture contents and temperatures, within various ranges which were selected as most likely to give a fairly uniform distribution of samples from a particular storage area. The information thus obtained is given in table 27.

The average change in fat acidity and germination for each group involves varying periods of time. For the purpose of comparison daily rates of change were computed using the group average number of days as shown and assuming that rates of change were constant during periods of constant temperature and moisture content. This assumption will generally be correct if the interval between samplings is short enough to avoid extreme variations in temperature and moisture content. It should be noted that in actual practice samples were taken much more frequently when conditions favored rapid deterioration of the wheat, and it appears that the assumed constant or average temperature and moisture content of the two samples has not resulted in appreciable error.

TABLE 27.—*Rate of deterioration found in wheat from selected portions of large storages, ventilated and unventilated, in the hard spring wheat area, the hard winter wheat area, and the soft winter wheat area*

SPRING WHEAT AREA

Group limits [1]		Group No. and treatment	Samples secured during first year of storage								Group No. and treatment	Samples secured after first year of storage							
			Samples in group	Group averages			Average change during period		Daily rate of change			Samples in group	Group averages			Average change during period		Daily rate of change	
Moisture content (percent)	Temperature			Moisture content	Temperature	Period between samplings	Fat acidity	Germination	Fat acidity	Germination			Moisture content	Temperature	Period between samplings	Fat acidity	Germination	Fat acidity	Germination
	° F.	Unventilated	No.	Pct.	° F.	Days	Units	Pct.	Units	Pct.	Unventilated	No.	Pct.	° F.	Days	Units	Pct.	Units	Pct.
0–11.9	0–32	1	11	10.47	23.6	67.0	+0.07	−0.18	+0.001	−0.003									
12–13.4		2	2	13.35	23.5	67.0	+.35	−1.50	+.005	−.022	16	48	13.18	22.0	85.2	−2.17	−1.29	−0.025	−0.015
13.5–14.4		3	25	13.94	20.5	58.4	−1.68	−1.67	−.029	−.028	17	105	13.77	21.2	74.4	−0.44	−1.52	−.005	−.020
14.5–15.4		4	3	14.93	21.3	44.6	+.63	−10.66	+.014	−.240	18	17	14.87	22.5	77.9	−.52	−5.18	−.008	−.066
15.5 or more											19	2	15.90	29.0	79.0	+.10	+7.00	+.001	+.089
0–11.9	33–69	5	19	10.40	55.8	97.0	−1.24	+.89	−.013	[2] +.009									
12–13.4		6	8	13.28	47.2	113.6	+2.78	−2.25	+.024	−.020	20	47	13.20	51.8	79.9	−.29	−2.00	−.004	−.025
13.5–14.4		7	34	13.98	50.9	89.9	+2.30	−4.15	+.025	−.046	21	233	13.85	54.6	60.5	+.44	−3.69	+.007	−.060
14.5–15.4		8	10	14.71	50.0	89.4	+2.52	−4.10	+.028	−.046	22	32	14.68	51.9	73.3	+.49	−6.28	+.007	−.085
15.5 or more																			
0–11.9	70–84																		
12–13.4		9	5	12.64	78.0	48.6	+4.46	−3.40	+.092	−.070	23	8	12.80	74.1	49.6	+2.87	+1.12	+.058	+.022
13.5–14.4		10	22	14.04	74.1	23.6	+.35	+2.57	+.015	[3] +.09	24	68	13.98	73.3	38.5	+1.78	−1.01	+.046	−.026
14.5–15.4		11	24	14.72	79.0	16.2	+2.75	−4.75	+.170	−.293	25	9	14.70	76.2	41.5	+1.96	−8.78	+.046	−.210
15.5 or more		12	3	15.70	77.6	24.0	+10.23	−20.66	+.426	−.858									
0–11.9	85 or more																		
12–13.4																			
13.5–14.4		13	5	13.88	86.8	10.6	+1.88	+0.60	+.177	[3] +.057									
14.5–15.4		14	12	15.00	89.3	9.6	+2.60	−12.40	+.271	−1.292									
15.5 or more		15	9	15.60	96.9	9.0	+8.40	−21.40	+.933	−2.378									

[1] The data are grouped, within the limiting values shown, according to the average moisture content and temperature of successive pairs of samples.

[2] Majority of samples taken during cold weather following summer storage.

[3] Majority of samples taken several weeks after wheat was stored, had higher germination than samples secured when bin was filled.

TABLE 27.—*Rate of deterioration found in wheat from selected portions o large storages, ventilated and unventilated, in the hard spring wheat area, the hard winter wheat area, and the soft winter wheat area*—Continued

SPRING WHEAT AREA—Continued

Group limits [1]		Group No. and treatment	Samples secured during first year of storage								Group No. and treatment	Samples secured after first year of storage							
				Group averages			Average change during period		Daily rate of change				Group averages			Average change during period		Daily rate of change	
Moisture content (percent)	Temperature		Samples in group	Moisture content	Temperature	Period between samplings	Fat acidity	Germination	Fat acidity	Germination		Samples in group	Moisture content	Temperature	Period between samplings	Fat acidity	Germination	Fat acidity	Germination
	° F.	Ventilated	No.	Pct.	° F.	Days	Units	Pct.	Units	Pct.	Ventilated	No.	Pct.	° F.	Days	Units	Pct.	Units	Pct.
9–11.9	0–32	1	4	11.55	15.2	67.7	−.68	+1.00	−.010	+.015	17	3	11.20	19.0	88.7	−.40	+.67	−.004	+.007
12–13.4		2	20	12.98	21.2	77.7	−1.63	+.70	−.021	+.009	18	53	12.94	21.8	89.9	−.41	−.69	−.004	−.008
13.5–14.4		3	40	13.99	18.9	80.1	−1.58	+.25	−.020	[4] +.003	19	52	13.82	17.8	76.4	−1.39	−1.48	−.018	−.019
14.5–15.4		4	9	14.70	21.6	60.2	−.02	−.22	−.0003	−.003	20	4	14.62	22.2	64.5	−1.12	−.75	−.017	−.012
15.5 or more																			
0–11.9	33–69	5	5	11.40	41.6	94.2	−2.22	−2.20	−.024	−.023	21	6	11.45	55.5	105.3	+.97	+4.17	+.009	[2] +.040
12–13.4		6	14	12.67	46.8	67.9	+2.14	−4.00	+.032	−.058	22	65	13.02	51.3	100.0	+.74	−.03	+.007	−.0003
13.5–14.4		7	55	13.97	48.7	64.0	+1.78	−3.22	+.029	−.050	23	81	13.90	52.9	77.4	+1.16	−1.04	+.014	−.013
14.5–15.4		8	24	14.79	57.9	61.1	+3.18	−.32	+.052	−.004	24	9	14.62	48.9	65.8	+1.78	−5.80	+.027	−.089
15.5 or more		9	1	15.60	69.0	30.0	+2.50	+2.00	+.083	[3] +.067									
0–11.9	70–84	10	3	11.23	74.0	16.0	+.56	−1.60	+.035	−.100									
12–13.4		11	3	13.05	72.5	13.0	+.56	−5.00	+.043	−.384	25	13	13.06	73.5	45.6	+.85	+2.31	+.019	[2] +.050
13.5–14.4		12	6	14.13	73.5	15.2	+1.88	+1.50	+.124	[3] +.098	26	28	13.94	73.6	36.6	+1.58	+.71	+.043	[2] +.019
14.5–15.4		13	35	14.87	76.8	16.0	+2.80	−2.12	+.175	−.137	27	9	14.70	73.2	31.8	−.26	−2.56	−.008	−.080
15.5 or more		14	11	15.91	77.6	19.4	+11.16	−11.45	+.575	−.590									
0–11.9	85 or more																		
12–13.4																			
13.5–14.4																			
14.5–15.4		15	17	14.98	90.8	10.5	+4.10	−9.65	+.390	−.918									
15.5 or more		16	7	15.87	89.3	13.4	+12.50	−13.86	+.933	−1.034									

[1] The data are grouped, within the limiting values shown, according to the average moisture content and temperature of successive pairs of samples.

[2] Majority of samples taken during cold weather following summer storage.

[3] Majority of samples taken several weeks after wheat was stored, and higher germination than samples secured when bin was filled.

[4] Majority of samples taken from bin in which a portion of wheat had been moved.

HARD WINTER WHEAT AREA

		Unventilated									*Unventilated*								
0–11.4	0–69	1	41	10.00	56.7	85.7	+.95	−.68	+.011	−.007	18	18	10.65	56.0	116.6	+.011	+3.2	2+.00009	[2] +.027
11.5–12.4		2	8	11.89	56.0	145.2	−.65	−5.00	−.004	−.034	19	16	11.78	51.8	134.5	+.31	+.2	5+.002	[2] +.001
12.5–13.4		3	1	12.70	54.0	175.0	−2.60	+8.00	−.015	+.046	20	3	12.90	43.7	141.3	+4.17	−12.3	3+.030	−.088
13.5–14.4		4	1	13.60	60.0	175.0	−5.70	+1.00	−.032	+.006	21	1	13.90	68.0	129.0	+1.40	−1.00	+.011	−.008
14.5 or more																			
0–11.4	70–84	5	14	9.84	78.1	58.5	+1.74	+3.64	+.030	[3] +.062	22	37	10.00	73.8	77.7	−1.60	+2.70	−.021	[4] +.034
11.5–12.4		6	11	11.83	75.2	157.6	+1.42	+1.27	+.008	+.008	23	5	11.78	72.2	107.8	+1.92	+5.00	+.018	[4] +.046
12.5–13.4		7	3	12.80	78.0	134.3	+2.93	−3.67	+.022	−.027									
13.5–14.4		8	5	14.28	83.4	9.4	+.60	−6.60	+.063	−.702									
14.5 or more		9	9	14.81	82.2	10.8	+3.28	−8.78	+.304	−.815	24	1	14.50	72.0	129.0	+3.40	−19.00	+.026	−.147
0–11.4	85–94	10	6	10.17	89.3	24.0	+5.22	+2.83	+.218	[3] +.118									
11.5–12.4		11	2	11.60	90.5	24.0	+4.50	−2.50	+.188	−.104									
12.5–13.4		12	4	13.25	90.0	14.0	+1.00	−3.50	+.071	−.250									
13.5–14.4		13	11	14.01	88.5	12.4	+2.50	−6.82	+.200	−.548									
14.5 or more		14	16	14.81	87.5	11.3	+4.00	−17.81	+.353	−1.574									
0–11.4	95 or more																		
11.5–12.4																			
12.5–13.4		15	2	13.30	95.5	13.5	+.50	−5.50	+.037	−.407									
13.5–14.4		16	2	13.90	97.5	14.0	+3.00	−9.50	+.214	−.678									
14.5 or more		17	4	14.92	102.0	14.5	+7.50	−18.00	+.517	−1.241									
		Ventilated									*Ventilated*								
0–11.4	0–69	1	26	10.00	55.3	119.7	+1.24	+1.08	+.010	+.008	16	29	10.84	43.0	108.9	−.57	+.00	3−.005	[2] +.00003
11.5–12.4		2	23	12.04	54.0	121.0	+1.20	−2.91	+.010	−.024	17	31	11.96	49.2	118.7	+.27	+.61	+.002	[2] +.005
12.5–13.4		3	40	12.84	56.6	106.9	+.43	−1.55	+.004	−.014	18	12	12.74	55.1	136.8	+.22	−2.67	+.002	−.020
13.5–14.4		4	1	13.80	65.0	61.0	+2.00	+5.00	+.033	+.082									
14.5 or more																			
0–11.4	70–84	5	23	10.62	75.0	126.0	+.37	+2.13	+.002	[3] +.018	19	18	10.86	74.9	74.2	+.70	+1.78	+.009	[4] +.023
11.5–12.4		6	23	12.09	77.3	75.8	+2.63	−1.26	+.034	−.016	20	26	11.96	75.2	68.5	+1.36	+4.08	+.020	[4] +.060
12.5–13.4		7	52	12.99	75.8	51.8	+2.44	−.15	+.047	−.002	21	9	12.87	72.7	88.9	+1.00	+7.56	+.011	[4] +.085
13.5–14.4		8	29	13.90	76.4	31.6	+2.81	+1.21	+.088	[3] +.038									
14.5 or more		9	39	14.98	78.5	18.1	+2.64	−5.00	+.146	−.275									
0–11.4	85–94	10	10	10.15	87.2	13.9	+1.25	−.70	+.089	[5] −.050									
11.5–12.4		11	5	12.16	86.0	62.0	+2.66	−7.20	+.043	−.116									
12.5–13.4		12	1	12.60	86.0	62.0	+1.00	−8.00	+.016	−.129									
13.5–14.4		13	5	14.10	87.8	12.6	+2.20	−3.20	+.174	−.254									
14.5 or more		14	13	15.12	88.1	10.5	+3.96	−13.46	+.376	−1.277									
0–11.4	95 or more																		
11.5–12.4																			
12.5–13.4																			
13.5–14.4																			
14.5 or more		15	5	14.92	102.4	15.6	+7.60	−31.60	+.487	−2.026									

[2] Majority of samples taken during cold weather following summer storage.

[3] Majority of samples taken several weeks after wheat mixed with a small portion having high moisture content, was stored.

[4] Majority of samples were secured during August and had slightly higher germination than preceding samples secured during late spring.

[5] Majority of samples were secured after a period of rapid drying from high initial moisture content.

TABLE 27.—*Rate of deterioration found in wheat from selected portions of large storages, ventilated and unventilated, in the hard spring wheat area, the hard winter wheat area, and the soft winter wheat area*—Continued

SOFT WINTER WHEAT AREA

Group limits [1]		Group No. and treatment	Samples secured during first year of storage								Group No. and treatment	Samples secured after first year of storage							
				Group averages			Average change during period		Daily rate of change				Group averages			Average change during period		Daily rate of change	
Moisture content (percent)	Temperature		Samples in group	Moisture content	Temperature	Period between samplings	Fat acidity	Germination	Fat acidity	Germination		Samples in group	Moisture content	Temperature	Period between samplings	Fat acidity	Germination	Fat acidity	Germination
	° F.	Unventilated	No.	Pct.	° F.	Days	Units	Pct.	Units	Pct.	Unventilated	No.	Pct.	° F.	Days	Units	Pct.	Units	Pct.
0–11.9	0–69																		
12–13.4		1	63	13.10	50.8	91.8	+.28	−1.78	+.003	−.019	13	43	13.11	60.0	143.3	+1.91	−4.40	+.013	−.030
13.5–14.4		2	17	13.83	56.8	124.7	+1.42	−4.47	+.011	−.035	14	35	13.89	60.5	168.1	+3.33	−6.17	+.020	−.036
14.5–15.4		3	9	15.02	65.1	21.7	+.44	−1.22	+.020	−.056	15	19	14.91	58.9	194.6	+3.35	−1.58	+.017	−.008
15.5 or more																			
0–11.9	70–84																		
12–13.4		4	21	13.24	81.0	36.7	+2.54	−2.43	+.069	−.066	16	5	13.18	72.8	124.0	+32.0	−1.80	+.026	−.014
13.5–14.4		5	25	13.98	77.4	44.6	+1.88	−9.48	+.042	−.212	17	14	14.04	75.2	80.4	+4.86	−14.36	+.060	−.178
14.5–15.4		6	115	14.78	78.6	17.2	+1.32	−5.10	+.076	−.296	18	30	14.82	78.9	62.5	+6.80	−17.90	+.109	−.286
15.5 or more		7	4	15.50	75.5	21.2	+1.75	−7.50	+.082	−.353	19	3	15.87	77.0	127.6	+13.70	−.33	+.107	−.003
0–11.9	85–94																		
12–13.4		8	11	13.26	87.5	20.4	+2.04	−2.27	+.100	−.111	20	1	13.10	85.0	28.0	+.30	−17.0	+.012	−.607
13.5–14.4		9	28	13.79	89.2	20.8	+2.62	−14.07	+.126	−.675	21	3	14.33	90.6	43.0	+9.27	−15.00	+.215	−.348
14.5–15.4		10	28	14.85	89.2	14.7	+2.85	−14.71	+.194	−1.002	22	53	14.95	89.2	32.6	+7.42	−8.11	+.228	−.248
15.5 or more											23	2	15.90	94.0	31.5	+6.90	−1.0	+.219	−.031
0–11.9	95 or more																		
12–13.4																			
13.5–14.4		11	9	13.67	97.3	17.2	+3.36	−12.11	+.195	−.703									
14.5–15.4		12	26	14.93	101.8	13.2	+8.65	−19.19	+.654	−1.450	24	23	14.98	98.0	20.6	+7.60	−.96	+.369	−.046
15.5 or more											25	6	15.65	98.5	23.2	+7.63	−5.50	+.330	−.237

		Ventilated									Ventilated								
0–11.9	0–69																		
12–13.4		1	5	13.34	46.8	94.2	−.06	−.80	−.0006	−.008	10	72	12.65	57.8	140.1	+1.00	−4.24	+.007	−.030
13.5–14.4		2	92	14.02	47.5	61.1	+.48	−1.54	+.007	−.025	11	44	14.02	50.0	93.2	+.32	−4.80	+.003	−.051
14.5–15.4		3	45	14.79	47.0	66.0	+.36	−3.27	+.005	−.049	12	28	14.85	55.8	75.5	+.85	−7.96	+.011	−.105
15.5 or more		4	13	15.82	40.0	70.5	+4.77	−5.85	+.068	−.082	13	6	16.15	63.8	72.5	+6.72	−1.00	+.093	−.013
0–11.9	70–84																		
12–13.4		5	14	13.14	78.2	18.1	+.58	−.86	+.032	−.047	14	29	12.67	76.1	107.6	+2.52	−3.90	+.023	−.036
13.5–14.4		6	98	14.12	76.4	15.9	+.40	−3.05	+.025	−.191	15	21	14.03	75.3	48.9	+1.50	−.57	+.030	−.011
14.5–15.4		7	121	14.67	76.6	13.4	+.86	−5.42	+.063	−.404	16	19	14.78	76.4	73.6	+4.08	−6.89	+.055	−.094
15.5 or more											17	2	16.15	83.0	26.0	+12.20	−1.50	+.169	−.058
0–11.9	85–94																		
12–13.4		8	1	13.30	86.0	8.0	+1.60	−4.0	+.200	−.500	18	4	13.15	87.8	39.8	+1.90	−6.00	+.048	−.150
13.5–14.4		9	6	14.10	89.3	11.7	+1.12	−11.5	+.096	−.985	19	5	13.70	86.6	50.2	+1.10	−24.80	+.022	−.494
14.5–15.4																			
15.5 or more											20	3	15.86	89.0	26.0	+10.40	−1.33	+.400	−.051
0–11.9	95 or more																		
12–13.4																			
13.5–14.4																			
14.5–15.4																			
15.5 or more																			

[1] The data are grouped, within the limiting values shown, according to the average moisture content and temperature of successive pairs of samples.

The rates of change shown in table 27 generally increase in a positive direction in the case of fat acidity and a negative direction in the case of germination as the moisture contents and temperatures of the wheat become higher. These data have been summarized in table 28 to more clearly indicate these trends. However, there are some exceptions to this tendency even in groups comprising reasonably large numbers of samples. Possible explanation for these contradictory data are as follows:

1. A decrease in fat acidity, instead of the increase which generally occurs during the storage of wheat, is indicated by a few of the group data. It should be noted that these decreases seem to occur only during periods of storage at low temperature.

2. Those groups which indicate a much greater rate of increase than might be expected, comprise samples which include small portions of wheat of high moisture content (footnote 2, table 28). Even though these portions of the sample were too small to appreciably affect the average moisture content, they could undergo sufficiently rapid deterioration to explain the abnormally high fat acidities.

TABLE 28.—*Summary of average rates of deterioration given in table 27* [1]

Group moisture limits (percent)	Average daily rate of deterioration, group temperature limits (° F.)							
	0–69		70–84		85–94		95 or more	
	Fat acidity	Germination	Fat acidity	Germination	Fat acidity	Germination	Fat acidity	Germination
	Units	*Percent*	*Units*	*Percent*	*Units*	*Percent*	*Units*	*Percent*
0–11.9	−0.003	+0.006	+0.050	+0.013	[2] −0.165	−0.012		
12.0–13.4	+.005	−.024	+.038	−.034	+.065	−.157	[3] +0.037	−0.407
13.5–14.4	+.003	−.031	+.054	−.106	+.144	−.463	+.204	−.690
14.5–15.4	+.013	−.063	+.114	−.289	+.302	−1.051	+.553	[4] −1.572
15.5 or more	+.080	−.082	+.331	−.372	+.933	−1.706	+.933	[4] −2.378

[1] The daily rate of change in fat acidity and germination for each group of more than one sample in table 27 within each of the above indicated group limits of moisture content and temperature was used in determining the average daily rate of change in this table.
[2] Samples in these groups were from bins in which some high moisture wheat was mixed with mostly dry wheat.
[3] Represents only one group of 2 samples.
[4] The daily rates of change for groups of samples from old wheat were not used in determining these averages.

3. Apparent improvement in the germination of wheat during storage is indicated by some of the group data. Reference to the footnotes in table 28 shows that most of these groups involve tests on new wheat or on samples secured when temperatures were comparatively high or low. These conditions are known to influence the dormancy (*5*, *8*) of wheat and therefore the test results. Since it was impractical to consider the history of each sample submitted, a uniform test procedure was used and no special methods applied to overcome this influence.

4. Some of the soft winter wheat sampled after the first year of storage had previously lost most of its germinating power. In such instances the difference between the germination of successive samples could not be large and the indicated rates of change should not be

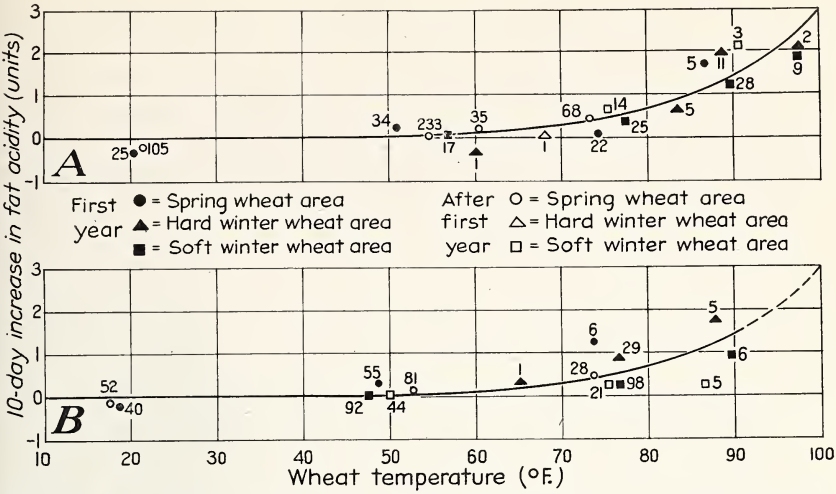

FIGURE 30.—Average increase in fat acidity units shown by wheat of 13.5 to 14.4 percent moisture content when stored for 10 days at various temperatures in: *A*, Unventilated bins; *B*, ventilated bins. Number of samples in each group is indicated.

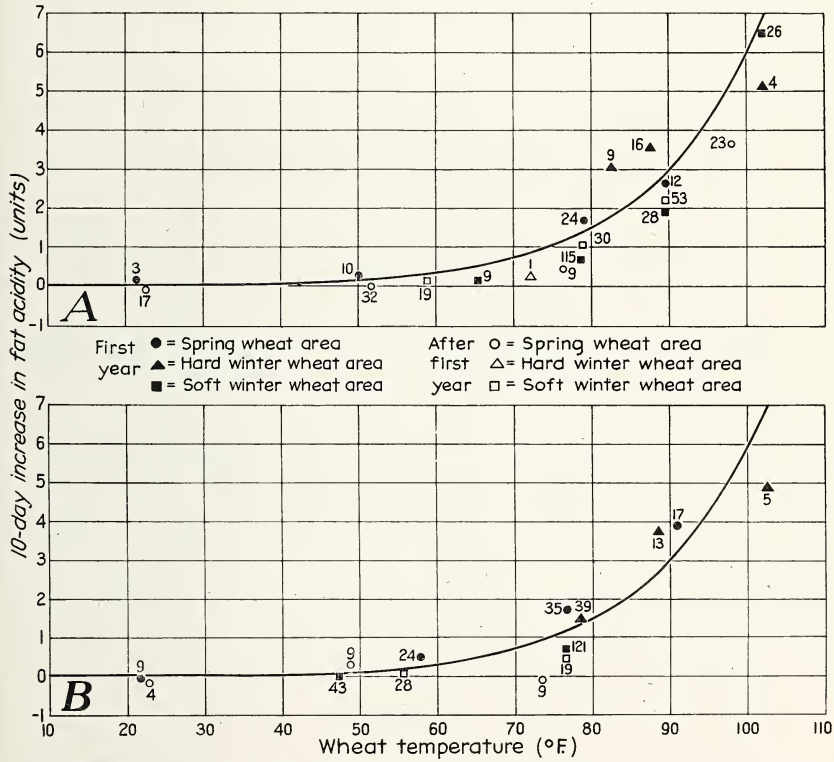

FIGURE 31.—Average increase in fat acidity units shown by wheat of 14.5 to 15.4 percent moisture content when stored for 10 days at various temperatures in: *A*, Unventilated bins; *B*, ventilated bins. Number of samples in each group is indicated.

considered representative of the deterioration that might be expected in sound wheat under similar conditions of temperature and moisture content.

Group data in only two moisture ranges, 13.5 to 14.4 percent and 14.5 to 15.4 percent, were available from both ventilated and unventilated storages in each of the three wheat-producing areas. Using the indicated daily rates of change in these groups, the changes in fat acidity and germination during a storage period of 10 days are shown

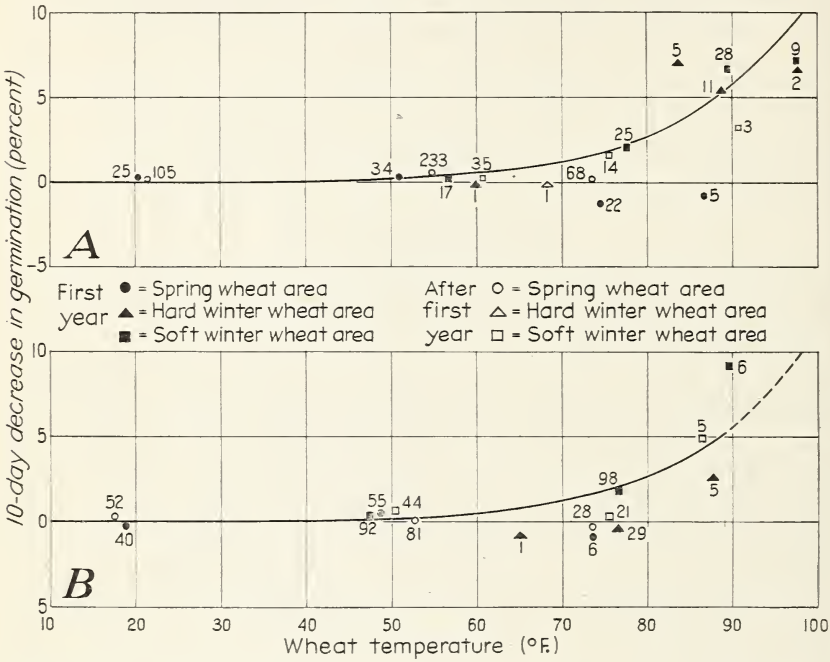

FIGURE 32.—Average decrease in germination percent shown by wheat of 13.5 to 14.4 percent moisture content when stored for 10 days at various temperatures in: *A*, Unventilated bins; *B*, ventilated bins. Number of samples in each group is indicated.

in figures 27 and 28. When these values are plotted on semilogarithmic charts they follow rather closely a straight line trend which would indicate a constant rate of increase in deterioration at progressively higher storage temperatures within the range observed. When plotted on ordinary arithmetic coordinates, these trend lines take the forms shown in the figures.

It is evident that the moisture content of wheat determines the rate of deterioration which occurs during storage at high temperatures such as those of midsummer. If, however, the temperature of the wheat is sufficiently low, there is little if any deterioration.

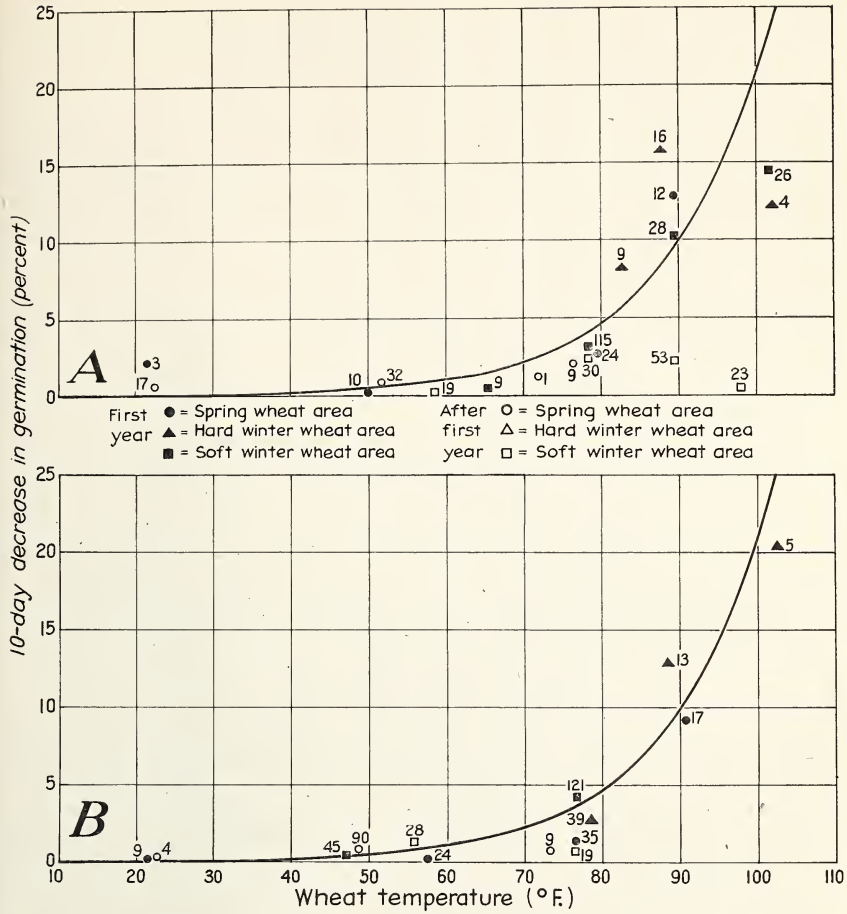

FIGURE 33.—Average decrease in germination percent shown by wheat of 14.5 to 15.4 percent moisture content when stored for 10 days at various temperatures in: *A*, Unventilated bins; *B*, ventilated bins. Number of samples in each group is indicated.

USE OF FUNGICIDES, INSECTICIDES, AND ABSORBENTS IN FARM WHEAT STORAGE

The addition of various chemicals or inactive materials to wheat to prolong its safe storage period was tested in the experimental bins and observed in several instances in the farm surveys. These admixtures may be classed according to their purpose as (1) fungicides, (2) insecticides, and (3) absorbents.

FUNGICIDES

Much of the heat developed in damp wheat is caused by the growth and respiration of micro-organisms, and a method of decreasing such growth by the use of a low-cost fungicide would materially reduce

the storage hazards. To be satisfactory for this purpose the chemical used must dissipate during storage or be easily removed when the wheat is marketed without reducing its commercial grade and must not affect the milling or baking properties of the flour.

In the survey of farm bins in 1936, the use of a mixture of air-slaked lime and flowers of sulfur added to the wheat was observed in a 920-bushel bin in Washington County, Md. The farmer had mixed the lime and sulfur in the proportions of 1 : 5 and had added about 0.015 pound of the mixture to each bushel of wheat. The first sample, drawn July 16, 1936, the day the bin was filled, showed the wheat to have a moisture content of 16.4 percent, a test weight of 55.3 pounds and to be of Sample grade, Soft Red Winter, Garlicky. On September 24 another average sample showed a drop in moisture content to 13.4 percent, in test weight to 55.0 pounds and an increase in grade to No. 4 Soft Red Winter, Garlicky. When the wheat was sold on January 12, 1937, it still had about this same moisture content and quality.

The success obtained with the lime and sulfur mixture in the above instance, led to further investigation of its use in experimental storages in 1937. As proportions of 3 or 4 parts of lime to 5 or 6 parts by weight of sulfur had been found most effective in mixtures to control plant diseases and fungi, these ratios were used in the experiments, applying various amounts to each bushel of wheat. At College Park, a 230-bushel bin, B–8, the west half of a wooden granary, was filled July 21, 1937, with wheat of 15.1 percent moisture content mixed with 0.1 pound per bushel of a lime and sulfur mixture in the ratio of 4 : 6. From the same lot of wheat the west half of a shaded metal bin, B–26, was filled with untreated wheat as a check on B–8. As shown in table 29, the first effect of the treatment on the wheat was to lower its test weight from 57.8 to 56.4 pounds per bushel and to add the statement "limed" to the grade designation. Grade data from consecutive average samples from the two bins are also shown in table 29. The wheat in the check bin, B–26, was sour when sampled April 23, 1938—277 days after being stored—while the wheat in bin B–8, treated with lime and sulfur, still had a natural odor when last sampled on March 5, 1941, after 1,321 days of storage. However, the official numerical grade of bin B–8 had dropped from No. 3 to No. 4 because of a decrease in test weight, and the quality as indicated by germination determination and fat acidity was very low. The results of baking tests, as shown by the data in table 30, also indicate deterioration in quality. It appears probable that deterioration in quality had taken place that was not fully revealed in the grade determinations.

TABLE 29.—*Grade data, percent germination, and fat acidity of wheat stored in experimental bins with different proportions and various rates of application of lime and sulfur mixture, at College Park, Md., Hays, Kans., and Fargo, N. Dak.*[1]

Ratio lime to sulfur	Pounds admixture per bushel	Quantity in bin	Average depth	Date	Moisture	Test weight per bushel	Dockage	Damage	Grade	Odor	Germination	Fat acidity
		Bu	*Ft.*		*Per-cent*	*Lb.*	*Per-cent*	*Per-cent*			*Per-cent*	*Units*
B-8, LIME AND SULFUR TREATED BIN, COLLEGE PARK												
4:6	0.1	230	5.8	July 21, 1937[2]	15.1	57.8	0.3	1.8	3, Tough, Garlicky	Natural	92	15
				do	15.1	56.4	.3	1.8	3, Tough, Garlicky, Limed.		91	18
				Jan. 28, 1938[3]	15.0	56.0	----	2.1	do		74	26
				Apr. 23, 1938	14.9	56.0	----	2.2	do		50	[4] 25
				July 21, 1938	14.9	55.0	----	2.8	4, Tough, Garlicky, Limed.		28	32
				Dec. 21, 1938	14.5	55.0	----	3.5	do		0	41
				May 4, 1939	14.3	55.0	----	4.0	do		0	50
				May 6, 1940	13.8	55.0	----	4.6	4, Garlicky, Limed		0	51
				Mar. 5, 1941	13.7	54.8	----	8.5	4, Garlicky, Limed, Weevily.		0	68
B-26, UNTREATED CHECK BIN FOR BIN B-8, COLLEGE PARK												
		180	5.7	July 21, 1937	15.2	57.8	0.3	1.8	3, Tough, Garlicky	Natural	91	14
				Jan. 28, 1938	15.2	58.0	----	1.8	2, Tough, Garlicky		71	24
				Apr. 23, 1938[5]	15.3	57.5	----	2.8	Sample, Tough, Garlicky.	Sour	66	24
B-20, FORMALIN-TREATED BIN, COLLEGE PARK												
	(6)	22	6.6	July 29, 1937[2]	15.5	57.3	0.4	2.2	3, Tough, Garlicky	Natural	85	17
				do.[3]	15.5	56.9	.4	2.2	do		74	21
				Aug. 19, 1937	15.5	57.0	----	2.3	do		67	19
				Spet. 9, 1937	15.5	57.0	----	2.4	do		60	23
				Oct. 1, 1937	15.5	57.0	.3	2.4	do		54	25
				Jan. 28, 1938	15.5	56.6	----	2.6	do		54	25
				May 16, 1938	15.5	56.0	----	2.9	do		23	33
				July 28, 1938[5]	15.5	55.4	----	3.2	Sample, Tough, Garlicky.	Musty	6	48
B-21, LIME-AND-SULFUR-TREATED BIN, COLLEGE PARK												
3:5	0.1	20	2.8	July 29, 1937[2]	15.5	57.3	0.4	2.2	3, Tough, Garlicky	Natural	85	17
				do.[3]	15.5	55.0	.4	2.2	4, Tough Garlicky, Limed.		88	15
				Aug. 26, 1937	15.4	54.7	----	2.3	do		69	26
				Sept. 30, 1937	14.8	54.8	.5	2.4	do		52	26
				Jan. 28, 1938[7]	15.1	54.5	----	2.5	do		58	27
B-22, LIME-AND-SULFUR-TREATED BIN, COLLEGE PARK												
4:6	0.04	20	2.8	July 29, 1937[2]	15.5	57.3	0.4	2.2	3, Tough, Garlicky	Natural	85	17
				do.[3]	15.5	55.2	.5	2.3	4, Tough, Garlicky, Limed.		92	15
				Aug. 26, 1937	15.3	54.7	----	2.3	do		77	24
				Sept. 30, 1937	14.9	54.8	.5	2.4	do		54	26
				Jan. 28, 1938[7]	14.9	54.4	----	2.5	do		61	27
B-15, UNTREATED CHECK BIN FOR BINS B-20, B-21, AND B-22 ABOVE, COLLEGE PARK												
		20	2.8	July 29, 1937	15.5	57.3	0.4	2.2	3, Tough, Garlicky	Natural	85	17
				Aug. 26, 1937	15.2	57.0	----	2.2	do		79	23
				Sept. 30, 1937	14.9	57.0	.4	2.4	do		55	26
				Jan. 28, 1938	15.0	56.5	----	2.6	do		62	26
				May 16, 1938	14.9	56.2	----	2.8	do		55	30
				July 28, 1938	14.9	55.8	----	3.2	Sample, Tough, Garlicky.	Musty	15	40

See footnotes at end of table.

TABLE 29.—*Grade data, percent germination, and fat acidity of wheat stored in experimental bins with different proportions and various rates of application of lime and sulfur mixture, at College Park, Md., Hays, Kans., and Fargo, N. Dak.*[1]—Con.

Ratio lime to sulfur	Pounds admixture per bushel	Quantity in bin	Average depth	Date	Moisture	Test weight per bushel	Dockage	Damage	Grade	Odor	Germination	Fat acidity
		Bu.	*Ft.*		*Per cent*	*Lb.*	*Per cent*	*Per cent*			*Per cent*	*Units*
H-28, LIME-AND-SULPHUR-TREATED BIN, HAYS												
4:9	0.15	25	2.7	July 2, 1937[2]	15.4	61.4	0.2	0	1, Tough	Natural	70	20
				do.[3]	15.4	57.3	.5	.1	3, Tough, Limed and Sulfured.	Lime and sulfur.	62	
				July 20, 1937	14.1	56.6		1.0	do		46	19
				Aug. 24, 1937	13.8	56.4		6.0	3, Limed and Sulfured.		22	39
				Sept. 7, 1937	13.5	56.1		17.0	Sample Limed and Sulfured.	Musty	26	43
H-29, LIME-AND-SULFUR-TREATED BIN, HAYS												
4:6	0.05	25	2.7	July 2, 1937[2]	15.4	61.4	0.2	0	1, Tough	Natural	70	20
4:6	.05	25	2.7	July 8, 1937[8]	15.4	58.0	.2	0	2, Tough, Sulfured	Sulfur	50	22
				July 20, 1937	14.7	56.7		2.5	3, Tough, Limed and Sulfured.		35	26
4:6	.05	25	2.7	Aug. 24, 1937[5]	14.0	56.5		9.0	Sample, Sulfured	Sulfur, musty	21	44
H-27, UNTREATED CHECK BIN FOR BINS H-28 AND H-29, HAYS												
		20	2.9	July 2, 1937	15.4	61.4	0.2	0	1, Tough	Natural	70	20
		20	2.9	July 20, 1937[5]	14.7	58.3		6.8	Sample, Tough	Musty	18	37
F-7, LIME-AND-SULFUR-TREATED BIN, FARGO												
4:6	0.1	482	8.0	Sept. 2, 1937[2]	15.6	53.2	3.4	0.1	4, Tough	Natural	90	17
				do.[3]	15.6	50.7	5.1	.5	5, Tough		85	17
				Nov. 2, 1937	15.1	50.8	4.3	.3	do		81	18
				Mar. 21, 1938	15.0	51.8	4.9	.1	do		81	18
				Mar. 25, 1938	15.1	51.1	1.7	.3	do		80	17
F-11, UNTREATED CHECK BIN FOR BIN F-7 ABOVE, FARGO												
		500	8.0	Sept. 2, 1937	15.6	53.2	3.4	0.1	4, Tough	Natural	90	18
				Nov. 2, 1937	14.8	53.5	3.4	.4	do		84	17
				Mar. 21, 1938	15.0	53.7	3.8	.1	do		77	17
F-28, LIME-AND-SULFUR-TREATED BIN, FARGO												
4:6	0.2	20	3.0	Sept. 7, 1937[2]	15.2	53.4	3.5	0.5	4, Tough	Natural	84	17
				do.[3]	15.4	51.2	4.8	.2	5, Tough		86	16
				Nov. 2, 1937	14.6	51.6	5.0	.3	do		81	16
				Mar. 22, 1938	15.4	51.0	5.6	.1	do		86	19
F-29, LIME-AND-SULFUR-TREATED BIN, FARGO												
4:6	0.01	20	3.0	Sept. 8, 1937[2]	15.2	53.4	3.5	0.5	4, Tough	Natural	84	17
				do.[3]	15.6	53.0	4.0	.3	do		85	17
				Nov. 2, 1937	14.8	53.0	4.9	.4	do		84	17
				Mar. 22, 1938	15.4	52.8	4.7	.3	5, Tough		83	17
F-31, UNTREATED CHECK BIN FOR BINS F-28 AND F-29 ABOVE, FARGO												
		20	3.0	Sept. 8, 1937	15.2	53.4	3.5	0.5	4, Tough	Natural	84	17
				Nov. 2, 1937	14.5	53.3	4.2	.6	4		88	18
				Mar. 22, 1938	15.2	52.5	4.3	.5	5, Tough		83	19

[1] All wheat in College Park bins of class Soft Red Winter and subclass Red Winter; that in Hays bins of class Hard Red Winter and subclass Dark Hard Winter; and that in Fargo bins of class Hard Red Spring and subclass Dark Northern Spring; all samples averages of entire bin.
[2] Before addition of lime and sulfur mixture.
[3] After addition of lime and sulfur mixture.
[4] Fat acidity of sample drawn May 16, 1938.
[5] First average sample showing abnormal odor.
[6] One-half pint of 1:1 solution of formalin and water was sprinkled on wheat while filling bin.
[7] Bin emptied.
[8] First sample drawn after filling. Bin filled July 2, 1937.

TABLE 30.—*Milling and baking data for untreated wheat and wheat treated with lime and sulfur mixture, from tests at College Park, and Fargo, in 1937*

Date	Flour			Basic baking data [1]			Remarks
	Ash	Yield	Loaf volume	Crumb color	Grain and texture	Crust color	
B-8, LIME-AND-SULFUR-TREATED BIN, COLLEGE PARK							
July 21, 1937	0.45	70.1	513	75, creamy gray	65, poor	Light brown	Odor and taste natural.
Apr. 23, 1938	.54	70.7	528	65, creamy gray	65, fair	do	Do.
July 21, 1938	.54	71.7	504	75, creamy gray	65, fair	do	Putrid odor in doughs; sour odor and taste in bread.
Dec. 21, 1938	.58	72.8	509	70, creamy gray	65, fair	do	Slight musty odor in flour, dough, and bread; slight musty taste in bread.
B-26, UNTREATED CHECK BIN FOR BIN B-8, COLLEGE PARK							
July 21, 1937	.45	70.6	510	75, creamy gray	70 poor	Light brown	Odor and taste natural.
Apr. 23, 1938	.49	70.0	540	62, creamy gray	55, poor, 65, fair.	do	Do.
July 20, 1938	.52	72.2	513	70, creamy gray	65, poor	do	Do.
F-7, LIME-AND-SULFUR-TREATED BIN, FARGO							
Sept. 2, 1937	.52	67.0	607	75, creamy	80, very good	Brown	Odor and taste natural.
Mar. 21, 1938	.53	67.0	624	70, creamy yellow.	75, good	do	Do.
F-11, UNTREATED CHECK BIN FOR BIN F-7 ABOVE, FARGO							
Sept. 2, 1937	.49	67.8	601	70, creamy	80, good	Brown	Odor and taste natural.
Mar. 21, 1938	.51	67.9	623	70, creamy	75, good	do	Do.

[1] Average of 2 bakes.

A group of small bins (capacity 20–22 bushels) also were filled with wheat treated with various admixtures in 1937 at College Park. All of the group, bins B–20, B–21, and B–22, and their check bin B–15, were of plain metal, and all except B–20 were 42 inches in diameter and 36 inches high. Bin B–20 was 24 inches in diameter and 8 feet high. All were filled on July 29, 1937, with wheat from the same lot, having a moisture content of about 15 percent. The wheat in bin B–20 had sprinkled on it while being filled ½ pint of a 1:1 solution of 37 percent formaldehyde and water. The strength of this solution was only about half that usually recommended for the control of fungi. A mixture of lime and sulfur in the ratio of 3:5 was mixed with the wheat in bin B–21 at the rate of 0.1 pound per bushel, and a 4:6 lime and sulfur mixture with the wheat in bin B–22 at the rate of 0.04 pound per bushel. The wheat in check bin B–15 received no admixture. Samples for grading, germination, and fat acidity determinations were taken from the bin from time to time and these results are shown in table 29.

The formalin solution did not retard the development of a musty odor, the wheat in bin B–20 and in check bin B–15 both grading sample grade due to abnormal odor at the same sampling date, after 1 year of storage. The decrease in germination and increase

in fat acidity were somewhat less in the treated bin, but this might be accounted for by the fact that the wheat in the treated bin, because of the different bin shape or other factors, lost more moisture while in storage. The addition of the lime and sulfur mixtures to the wheat in bins B–21 and B–22 had the immediate result of lowering the test weight enough, as shown in table 29, to cause a drop in numerical grade from No. 3 to No. 4. At the time treated bins B–21 and B–22 were emptied, after 6 months of storage, the condition of the wheat as measured by percent damage, germination, and fat acidity was about the same in both bins and in the check bin B–15. No samples were removed from the small bins for milling and baking tests.

The effect of two different proportions of a 4:6 lime and sulfur mixture on stored wheat was tested in two small bins at Hays in 1937, H–28 and H–29. Both bins were 40 inches in diameter and 36 inches high, of metal insulated with 3 inches of granulated rock wool. A check bin, H–27, of the same size but not insulated, was filled with wheat from the same lot having an initial moisture content of 15.4 percent. The lime and sulfur mixture was added to the wheat in bin H–28 at the rate of 0.15 pound per bushel and to bin H–29 at 0.05 pound per bushel. The test weight showed an immediate drop, in bin H–28 of 4.1 pounds and in H–29 of 3.4 pounds. (The first sample from bin H–29 was drawn 6 days after storage.) As shown by the grade data in table 29, the wheat with the lime and sulfur admixtures stayed in storage slightly longer before developing a musty odor than did the untreated wheat. However, it should be remembered that the treated bins and the check bin were not identical in construction. No samples for milling and baking tests were taken from the Hays bins.

One large ventilated and two small unventilated bins were filled in 1937 at Fargo, with wheat that had been treated with a mixture of lime and sulfur in the proportion of 4:6. Bin F–7, the east half of a 1,000-bushel round metal bin, was fitted with horizontal flues for ventilation, and filled with 482 bushels of wheat, moisture content of 15.6 percent, mixed with the lime and sulfur at the rate of 0.1 pound per bushel. Bin F–11, the west end of a wooden bin fitted with the same type of ventilation flues, was filled with 500 bushels of untreated wheat from the same lot, as a check. The average test weight of the wheat dropped 2.5 pounds with the addition of the lime and sulfur, resulting in a decrease in numerical grade from No. 4 to No. 5. On March 21, 1938, after 200 days in storage, bin F–7 was emptied and the wheat sold. During this period no significant differences except that of test weight were noted in the wheat stored in the two bins; however, because of the lime and sulfur dust the treated wheat contained slightly more dockage than the untreated. When the wheat was removed from bin F–7 in March, it was cleaned in a fanning mill to blow out as much of the admixture as possible. This cleaning reduced the amount of dockage but did not increase the test weight. After cleaning the wheat still had a dull color, easily detected.

Occasional samples were taken for grading purposes to represent the top, middle, and bottom portions of the bin and it is interesting to note that despite the care that was taken to distribute the lime and sulfur mixture uniformly throughout the bin, the concentration

in the bin bottom apparently was greater than in the top. In the case of the wheat in bin F–7 the loss in test weight from the original was 1.2 pounds for the wheat in the top of the bin, 2.0 pounds for that in the middle, and 2.5 pounds for the wheat in the bin bottom.

Samples drawn for milling and baking tests did not show any significant differences between the quality of the wheat in these two bins (F–7 and F–11) as shown by the determinations given in table 30.

Two 20-bushel bins were also filled with lime-and-sulfur-treated wheat at Fargo in 1937. Bin F–28, of plain metal, uninsulated, had a 4:6 lime and sulfur mixture added to the wheat at the rate of 0.2 pound per bushel; the wheat in F–29, a small insulated bin, was treated with the same admixture at the rate of 0.01 pound per bushel. Bin F–31, another small insulated bin, was filled with similar wheat, but untreated, as a check on bins F–28 and F–29. As in the other tests where this admixture was used, the test weight dropped immediately, as shown in table 29—2.2 pounds per bushel in bin F–28 and 0.4 pound per bushel in F–29. No other significant differences in the quality of the treated and untreated wheat were noted up until the treated wheat was disposed of, on March 21, 1938. No samples were taken for milling and baking tests.

SUMMARY OF FUNGICIDE STUDIES

1. The most outstanding result observed in the use of a mixture of lime and sulfur for treating wheat in storage is the immediate drop in test weight. In five of the eight tests the reduction in test weight was enough to lower the numerical grade one grade, and in one test enough to lower it two grades. In only one case (F–29, 1937, Fargo) was the grade not lowered, and in that test only 0.01 pound of the mixture was added to each bushel of wheat. In five of the eight tests the word "limed" or "lime-sulfured" was added to the grade designation. Where wheat is sold by grade, these designations would lower the price received for the grain. Other objections might be found to the treated grain when sold by sample.

2. There was little relation between the amount of admixture used per bushel of wheat and the loss in test weight.

3. The lime and sulfur admixture was of some value in postponing the development of abnormal odors. At College Park, the untreated wheat in bin B–26 was sour when sampled after 277 days in storage while the treated wheat in bin B–8 still had a normal odor after over 1,000 days of storage, although the wheat had deteriorated materially as measured by fat acidity and germination. The untreated wheat in small bin H–27 at Hays, was musty when sampled 18 days after filling; the wheat in bin H–28, treated with lime and sulfur at the rate of 0.15 pound per bushel did not show a musty odor until after 67 days of storage, and that in bin H–29, treated at the rate of 0.05 pound of lime and sulfur per bushel, not until after 47 days of storage. The remainder of the lime-and-sulfur-treated wheat, with the checks of untreated wheat, was moved before abnormal odors were observed.

4. The results of the baking tests were not alike, possibly due to the difference in character of the two classes of wheat. In the case of the soft red winter wheat at College Park, a decided lowering of the quality of the flour, dough, and bread from the treated wheat was observed, while in the case of the Fargo hard red spring wheat, no

difference between the flour, dough, and bread from the treated and untreated wheat could be detected.

5. The use of a 1:1 formalin-water solution at the rate of ½ pint for 22 bushels was not beneficial in prolonging the period of safe storage; neither did it lower the test weight as did the lime and sulfur mixture. Further tests may prove higher concentrations of formalin to be beneficial.

Insecticides

Two large bins (U–2 and U–6) were filled in 1937 at Urbana with wheat treated with a pyrethrum compound [13] at the rate of 0.08 pound per bushel in bin U–2 and 0.11 pound per bushel in bin U–6, in an effort to find a method of permanently preventing insect infestation. When observations were discontinued September 23, 1937, insects had appeared in bin U–6 in great enough numbers to affect the grade. At that time two bran bugs were noted in an average sample from bin U–2. On October 13, 1937, the two bins were emptied and the wheat disposed of except for 20 bushels from each bin which was placed in two small metal bins. Bin U–23 was filled from large bin U–2 and bin U–24 from large bin U–6. Insects appeared in both bins the following summer. From the above results it is evident that the pyrethrum dust was not an effective insecticide at the concentration and dosages used in these experiments.

Absorbents

The use of various materials as absorbents to remove excess moisture from stored wheat was investigated in the experimental bins in 1936 and 1937, and their use was observed in farm bins in other years. Because of the different natures of the various absorbents, they will be discussed separately.

STRAW

Various methods of distributing the straw throughout the wheat were tried in the experimental bins. In 1936 two small bins were treated with straw at Fargo and at Hays. At Fargo wheat straw from the 1935 crop was chopped in a hammer mill to lengths varying between one-half and 1 inch, and 40 pounds mixed evenly throughout the 20 bushels of wheat in each of bins F–34 and F–35. At this time the straw moisture content was 5.9 percent and the wheat moisture content 15.4 and 15.6 percent. The straw was taken from an old stack and had not been dried. At the end of 11 days the wheat had been reduced 1.2 percent in moisture content while similar small bins without the straw admixture had lost only 0.6 percent. At Hays, in 1936, two small bins, H–17 and H–18, were filled with wheat with an initial moisture content of 17.7 percent and 17.8 percent, respectively, with 10 pounds of air-dried unchopped wheat straw distributed through the 20 bushels of wheat in each bin. Average samples drawn 8 days after filling showed no more moisture loss from the wheat than occurred in a similar small bin, H–15, without the straw treatment, and the

[13] The pyrethrum compound consisted of 90 percent by weight of talcum and 10 percent by weight of fullers earth and pyrethrum extract or similar concentrate.

wheat reacted in storage in the same manner in the three bins (H–15, H–17, and H–18) all heating and developing a sour odor in the 8-day period.

Several tests with straw as an admixture were made at Hays and at Urbana, in 1937. At Hays bin H–2–E, the east half of a 500-bushel round metal bin, was filled with 210 bushels of wheat having a moisture content of 15.3 percent; 1.5 pounds per bushel of unchopped straw was distributed evenly throughout the bin. Bin H–4–E, the east half of a 500-bushel concrete stave silo was filled at the same time with 230 bushels of similar wheat, but instead of spreading the loose straw through the bin, the same amount per bushel (1.5 pounds) was placed in mesh bags and these distributed at random throughout the bin, with the idea in mind that the straw would be more easily removed. There were 110 of the bags, 1 foot in diameter and 2 feet long, each containing slightly over 3 pounds of straw. Bin H–1–E, the east half of another 500-bushel round metal bin, was filled with wheat from the same lot, but having a moisture content of 15.4 percent instead of 15.3 percent, as a check on the performance of the straw in bins H–2–E and H–4–E. In 15 days, after the wheat had heated and turned musty in all three bins, the straw was removed from the wheat. At this time the wheat in the bins with loose straw had dropped 0.4 percent in moisture content, that with the sacked straw 0.2 percent, and that in the check bin 0.8 percent. The wheat was caked in all the bins except where in bin H–2–E it was in direct contact with loose straw.

At Urbana unchopped straw was added to wheat in two 20-bushel plain metal bins. In bin U–17, 20 pounds and in bin U–21, 40 pounds of straw was distributed in thin layers through the wheat. A small shaded bin, U–15, was used as a check bin. The initial wheat moisture content was 14.1 percent in all cases. When the straw was removed, after 42 days of storage, the wheat moisture content in bin U–17 had dropped to 13.7 percent and in U–21 to 13.8 percent, while that in the check bin, U–15, was 13.9 percent. Ordinarily the moisture content in small unshaded bins varies more than in shaded bins, so the differences noted in the Urbana experiments cannot be considered significant.

In the tests using straw as an absorbent the only successful method was to chop the straw and distribute it evenly through the wheat, as was done at Fargo in 1936, so that very intimate contact between the straw and wheat was obtained. The 0.6 percent of moisture removed from the wheat over that lost from the wheat in identical check bins, by calculation raised the straw moisture content to approximately 12 percent.

PEAT

Because peat moss is highly absorbent, cheap, and light weight, it was included in the investigations of absorbent materials. In 1936 small bins B–12 and B–15 were filled at College Park with wheat having a moisture content of about 18 percent and having air-dried peat moss mixed through the wheat at rates of 3.2 and 2.1 pounds per bushel respectively. As shown in table 31, in 27 days the moisture content dropped about 3.6 percent in both bins but the wheat had

turned sour during that period. No check bins were used for this test. Two small bins (U–14 and U–24) were filled at Urbana the same year with wheat having a moisture content of about 17.6 percent. Peat moss, ground to pea size, was mixed with the wheat at the rate of 3.3 pounds per bushel. Bins U–15 and U–25 were used as checks. The relative moisture losses and wheat deterioration are shown for the treated and untreated bins in table 31. Although somewhat more moisture was lost from the treated bins, all wheat had developed a musty odor by the time the first samples were drawn, 81 days after storage. However, the loss in germination was slightly less in the wheat with the peat admixture.

In 1937 the use of peat moss in small sacks distributed at random through the wheat was investigated in a 20-bushel bin, H–30, at Hays. Seven mesh bags 1 foot in diameter and 18 inches long were each filled with 3.7 pounds of the moss. Bin H–27, without the admixture, was used as a check. As shown in table 31, although there was little difference in the rate of moisture loss from the two bins, the treated wheat did not develop an abnormal odor during the 46 days of the test period, while the wheat without the peat moss admixture was musty when sampled after only 18 days of storage.

TABLE 31.—*Grade data, percent germination, and fat acidity of wheat stored in experimental bins with peat moss as an admixture*

Air dry peat per bushel	Quantity of wheat	Average depth	Date	Moisture	Test weight per bushel	Dockage	Damage	Grade	Odor	Germination	Fat acidity
EXPERIMENTAL BIN AT COLLEGE PARK,[1] B–12, BIN WITH PEAT ADMIXTURE											
Lb.	*Bu.*	*Ft.*		*Pct.*	*Lb.*	*Pct.*	*Pct.*			*Pct.*	*Units*
3.2	12	3	July 21, 1936[2]	18.0	56.2	1.1	1.9	Sample, Garlicky	Garlicky	92	------
3.2	12	3	Sept. 17, 1936	14.4	56.4	1.1	45.0	Sample, Garlicky, Tough	Sour	15	------
EXPERIMENTAL BIN AT COLLEGE PARK,[1] B–15, BIN WITH PEAT ADMIXTURE											
2.1	18	3	July 21, 1936[2]	17.9	56.2	0.9	1.7	Sample, Garlicky	Garlicky	98	------
2.1	18	3	Sept. 17, 1936	14.2	56.3	.9	36.0	Sample, Garlicky, Tough	Sour	0	------
EXPERIMENTAL BIN AT URBANA,[1] U–14, PLAIN METAL BIN WITH PEAT ADMIXTURE											
			July 3, 1936[2]	17.5	59.4	0.3	2.3	Sample, Garlicky	Natural	81	------
3.3	15	3	do[2]	16.7	59.6	.3	3.7	do	do	80	------
3.3	15	3	Sept. 23, 1936	14.3	56.7	----	70.0	Sample, Garlicky, Tough, Weevily.	Musty	37	------
EXPERIMENTAL BIN AT URBANA,[1] U–15, PLAIN METAL UNTREATED CHECK BIN FOR U–14 ABOVE											
	20	3	July 3, 1936	17.5	59.4	0.3	2.3	Sample, Garlicky	Natural	81	------
	20	3	Sept. 23, 1936	15.1	56.2	----	65.0	Sample, Light Garlicky, Tough.	Musty	19	------
EXPERIMENTAL BIN AT URBANA,[1] U–24, INSULATED METAL BIN WITH PEAT ADMIXTURE											
			July 3, 1936[2]	17.6	59.4	0.1	2.0	Sample, Light Garlicky	Natural	83	------
3.3	15	3	do[2]	16.8	60.0	.6	2.9	Sample, Garlicky	do	77	------
3.3	15	3	Sept. 23, 1936	14.8	57.0	----	60.0	Sample, Garlicky, Tough, Weevily.	Musty	28	------

See footnotes at end of table.

TABLE 31.—*Grade data, percent germination, and fat acidity of wheat stored in experimental bins with peat moss as an admixture*—Continued

EXPERIMENTAL BIN AT URBANA,[1] U-25, INSULATED UNTREATED CHECK BIN FOR U-24 ABOVE

Air dry peat per bushel	Quantity of wheat	Average depth	Date	Moisture	Test weight per bushel	Dockage	Damage	Grade	Odor	Germination	Fat acidity
Lb.	*Bu.*	*Ft.*		*Pct.*	*Lb.*	*Pct.*	*Pct.*				
	20	3	July 3, 1936	17.6	59.4	0.1	2.0	Sample, Light Garlicky	Natural	83	------
	20	3	Sept. 23, 1936	15.8	56.3	----	75.0	Sample, Light Garlicky, Weevily.	Musty	11	------

EXPERIMENTAL BIN AT HAYS,[4] H-30, PLAIN METAL BIN WITH PEAT ADMIXTURE IN SMALL SACKS

	25	3.2	July 2, 1937 [2]	15.3	60.8	0.9	0.1	1, Tough	Natural	66	20
	25	3.2	July 13, 1937	14.9	59.5	1.0	.1	2, Tough	do	44	25
	25	3.2	Aug. 17, 1937	13.8	58.4	----	5.0	3	do	32	39

EXPERIMENTAL BIN AT HAYS,[4] H-27, PLAIN METAL UNTREATED CHECK BIN FOR H-30 ABOVE

	20	2.9	July 2, 1937	15.4	61.4	0.2	0	1, Tough	Natural	70	20
	20	2.9	July 13, 1937	15.1	59.3	----	.3	2, Tough	do	27	27
	20	2.9	July 20, 1937	14.7	58.3	----	6.8	Sample, Tough	Musty	18	37

[1] All wheat of class Soft Red Winter and subclass Red Winter; all samples averages of entire bin.
[2] Before addition of peat moss.
[3] After addition of peat moss.
[4] All wheat of class Hard Red Winter and subclass Dark Hard Winter.

OATS

Oats are the principal horse grain feed throughout the spring wheat area and usually a certain amount is carried over to the next harvest, at which time it may be quite dry. Because of this fact and because it could be easily cleaned from the wheat with no harm resulting to either grain, it was tested at Fargo in 1937 for use as an absorbent admixture. In bin F-8, the west half of a 1,000-bushel metal bin with perforated bottom, 350 bushels of wheat, moisture content 15.6 percent, was thoroughly mixed with 189 bushels of oats having a moisture content of 10.7 percent. The moisture content of the wheat a few hours after the oats were added had dropped 0.6 percent. The grain was classed as "Mixed Grain." After approximately 3 weeks of storage, the oats were removed by a disk cleaner, restoring the wheat to its original grade. (See table 32.) A higher concentration of oats was used in two small bins, F-36 and F-37. In bin F-36, 5 bushels of whole oats and 11 bushels of wheat were mixed together and in bin F-37 the same proportions of ground oats and wheat (whole) were used. As shown in table 32 from 0.6 to 0.8 percent moisture was taken up by the oats. The ground oat dust clinging to the wheat when the fat acidity tests were made caused abnormally high acidity.

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TABLE 32.—*Grade factor, percent germination, and fat acidity data for wheat mixed with oats of 10.7 percent moisture content at Fargo*

Sample type	Oats per bushel	Quantity of wheat	Average depth	Date	Moisture content	Test weight per bushel	Dockage	Damage	Grade [1]	Odor	Germination	Fat acidity
	Pounds	*Bushels*	*Feet*		*Percent*	*Pounds*	*Percent*	*Percent*			*Percent*	*Units*
F-8, WITH WHOLE OATS												
Average [2]				Sept. 2, 1937	15.6	53.2	3.4	(3)	4, Tough	Natural	90	18
Do.[4]	1.8	350	8.0	do	15.0	47.6		0.1	Mixed grain,[5] Tough	do	89	18
Last (before cleaning)	1.8	350	8.0	Sept. 21, 1937	14.8	48.5		.2	Mixed grain,[6] Tough	do	86	21
After cleaning	0	350	5.2	Sept. 28, 1937	14.5	53.0	5.0	.2	4	do	80	22
F-36, WITH WHOLE OATS												
Average [2]				Sept. 8, 1937	15.6	53.2	3.4	(3)	4, Tough	Natural	90	18
Do.[4]	3.2	16	2.0	do	14.8	54.0	14.8	0.2	do	do	90	17
Do	3.2	16	2.0	Mar. 22, 1938	14.6	48.2		0	Mixed grain,[7] Tough	do	82	17
F-37, WITH GROUND OATS												
Average [2]				Sept. 10, 1937	15.6	53.2	3.4	(3)	4, Tough	Natural	90	18
Do.[4]	3.2	16	2.5	do	15.0	50.5	10.4	0.6	5, Tough	do	90	26
Do	3.2	16	2.5	Mar. 22, 1938	14.6	52.0	6.9	.2	do	do	82	25

[1] All wheat of class Hard Red Spring and subclass Dark Northern Spring except where noted.
[2] Before addition of oats. Wheat from same lot as used to fill bin F-11, 1937.
[3] Trace.
[4] After addition of oats.
[5] Wheat 78 percent, oats 14 percent, other grain 2 percent, foreign material 6 percent.
[6] Wheat 84 percent, oats 10 percent, other grain 1 percent, foreign material 5 percent.
[7] Wheat 81 percent, oats 14 percent, foreign material 5 percent.

MISCELLANEOUS

A number of other substances were mixed with wheat in the experimental bins or observed in use on farms. These included broken brick and tile, logs, posts, lime,[14] fine sand, and soda. No drying or improvement in the quality of the stored wheat that could be attributed to their use was observed.

MOVING AND CONDITIONING WHEAT

Turning is a general practice among terminal and country elevator operators to prevent heating and deterioration of wheat while in storage. It was recognized that turning wheat in farm bins might also result in safer storage because of the resultant cooling and drying and by the redistribution and breaking up of pockets of wheat having a higher moisture content than the average for the bin. A bin was constructed at Urbana incorporating an elevator to move the grain, so that the effects on wheat temperature, moisture, and rate of deterioration could be observed. The wheat in a bin at Fargo was also moved and was observed for several years in comparison with similar wheat that had not been moved. In addition, throughout the period of the investigation a large amount of wheat was moved at the various locations after the wheat had started to heat, in an attempt to cool and dry it enough to prevent further deterioration. These experiments and observations are discussed in the following sections.

Bin With Elevator at Urbana

One of the disadvantages of turning wheat, besides the labor involved, is that additional storage space must be provided for the grain to be moved. In 1936 one of the movable bins, U–7, at Urbana was provided with a hopper bottom and a small vertical elevator in the center so that wheat could be removed from the bottom of the hopper, elevated to the top of the 9-foot elevator leg, and then dropped back on the top of the wheat, in the same bin. The hopper bottom extended from the bin walls to the center of the bin at about a 45° slope. The elevator, with a 9-foot leg, was operated with a ¼-horsepower electric motor, and had a capacity of about 15 bushels per hour.

On July 4, 1936, 298 bushels of wheat of slightly over 14 percent moisture content, were placed in bin U–7. Complete grade factor data are given in table 41 of the appendix. As the bin was filled, small numbered slips of cardboard were distributed through the wheat and their positions recorded. The elevator was operated intermittently during the first week of storage for a total of 13 hours, the daily period ranging from 30 minutes on July 4 and 6, to 3 hours on July 10. Observation of the numbered slips indicated that the wheat from the vicinity of the elevator leg received the most turning, no movement occurring at the bin walls. Because of the low wheat moisture content no heating would probably have occurred had the wheat not been moved.

[14] For a detailed discussion of the use of high calcium pulverized quicklime, see (*3*).

In 1937 bin U–7, was refilled on July 7 with 250 bushels of wheat of 14.7 percent moisture content. The elevator was not started until August 10, 45 days after the bin was filled, and then run intermittently for a total of 38 hours, until the bin was emptied on August 23, 1937. Although wheat with a moisture content of 14.7 percent would be expected to heat under the conditions that prevailed, the wheat in bin U–7 showed no indication of heating. The elevator leg in the center of the bin may have allowed the escape of some heat, and the bin surface exposed to air was also somewhat increased by the hopper bottom. Complete grade data for the 1937 wheat in bin U–7 are given in table 41 of the appendix.

Moving Wheat at Fargo

An example of increasing the length of safe storage of wheat by redistributing moisture that has accumulated to a dangerous point in certain parts of the bin is provided by tests with a 500-bushel double wall wood bin, F–12, at Fargo. This bin is the east half of a granary 12 by 14 feet in floor area. It was filled with 500 bushels of 14.5 percent moisture content wheat on August 17, 1937, from the same lot of wheat used to fill bins F–1 (metal) and F–10 (wood). On March 21, 1938, 3 wagonloads, or about 200 bushels of the wheat in bin F–12 was removed through a gate in the bottom of the bin, and then replaced through the roof filling door. As a portable elevator was used for both emptying and refilling the bin, very little shoveling was required in the operation. Although only about two-fifths of the wheat was turned, the high moisture areas in the upper part of the bin were broken up and the length of storage materially increased. The wheat in bin F–12 had not acquired an abnormal odor in any part of the bin at the latest sampling (January 6, 1941), after 1,266 days in storage, although the test weight had lowered 0.6 pound from the original, the germination had decreased to 39 percent from the original 89 percent, and the fat acidity had increased to 36.1 units from the original 19.0. The wheat of similar initial moisture content stored in bins F–1 (metal) and F–10 (wood), but which had not been moved, turned sour or musty in about 1½ years. (See p. 10) for a detailed discussion of bins F–1 and F–10.) Complete grade data for bins F–1, F–10, and F–12 is given in table 35 of the appendix.

Use of Solid Carbon Dioxide for Cooling Wheat

Where wheat has started to heat in the bin, and the problem is to cool it quickly during hot weather, it was thought that carbon dioxide ice might be effectively used. Accordingly, when the 236 bushels of wheat in bin B–2 at College Park (1936) 16.4 percent moisture content, heated to an average temperature of 103° F., with a high temperature of 121° F., near the bin center, it was emptied to a canvas spread in the sun, and, on the same day returned to the bin by shoveling. During the refilling, 300 pounds of dry ice, broken into chunks about the size of a common brick, was uniformly distributed through the wheat. The average wheat temperature lowered from 103° to 90° in 3 days, as compared with a temperature loss of only 2° to 5° observed in other College Park bins where the wheat was moved without the addition of solid carbon dioxide. However, the carbon

dioxide was not effective in preventing further heating, as the average wheat temperature had increased to 99° a week later and the wheat had to be turned again. The highest wheat temperature just before moving this second time was 102°, near the south bin wall.

Other Wheat-Moving Observations

In many cases, especially in 1936 when much high moisture wheat was stored in the experimental bins, it was found necessary to move or turn the wheat to prevent excessive spoilage. Although the moving of the wheat was not planned as part of the investigation, observations as to wheat temperature, moisture, test weight, odor, etc., were made before and after moving, along with air temperatures, relative humidity, and wind velocity. The data for 45 separate moving operations are given in table 33. The method of moving—that is by elevator, shovel, etc.—is given in the remarks column.

A study of the table brings out certain facts which may be summarized as follows:

1. Moving was of little value in reducing the average moisture content of the wheat, even under the very low relative humidities prevailing at Hays in 1936 (tests Nos. 6 to 21 of the table). As the wheat in the moving operation at all of the stations except College Park was probably exposed to the air longer than it would be under ordinary farm conditions where shorter elevators are usually used, it is evident that turning cannot be recommended as a method of drying wheat. However, much benefit may be derived from the mixing of damp wheat with dry wheat placed in the same bin, if the operation is undertaken before marked heating takes place. This is well illustrated by the data from the Fargo bins obtained in 1938, when combined wheat of very uneven moisture content was stored (tests Nos. 1 to 5 of the table). Where the wheat was merely shoveled into a pile and then returned to the bin the same day, no drying was observed (tests Nos. 37 to 45 of the table).

2. Unless the air temperature is well below the average wheat temperature, little cooling of the wheat will take place. However, here again the mixing of hot wheat with cooler wheat may break up danger areas before spoilage results, but would have a tendency to make the cool wheat more subject to spoilage.

3. In almost all of the tests where wheat was run through an elevator the test weight was increased. In several cases this increase in test weight was large enough to raise the numerical grade. At College Park, where the grain was merely shoveled from the bin to a canvas and then returned, also by shoveling, there was very little increase in test weight. It is probable that the polishing of the grain by the movement had more to do with the test weight increase than did the removal of moisture.

4. In none of the tests where the average samples from the bin had a musty or sour odor was the odor improved by moving. However, in those tests where only portions of the bin were sour, the mixing dissipated the abnormal odor so that it could not be detected in an average sample.

TABLE 33.—*Summary of wheat condition before and after moving by various methds,*

Test No.	Bin No.[1]	Amount of wheat	Date of original filling	Date when moved	Wheat: Moisture content: Before moving: Average	Wheat: Moisture content: Before moving: Maximum	Wheat: Moisture content: After moving: Average	Wheat: Moisture content: After moving: Maximum	Wheat: Temperature: Before moving: Average	Wheat: Temperature: Before moving: Maximum	Wheat: Temperature: After moving: Average	Wheat: Temperature: After moving: Maximum
		Bu.			*Pct.*	*Pct.*	*Pct.*	*Pct.*	*° F.*	*° F.*	*° F.*	*° F.*
1	F-3	450	Aug. 3, 1938	Aug. 23, 1938	15.0	16.0	14.4	14.8	88	113	76	81
2	F-4	440		Sept. 10, 1938	14.3	15.8	14.2	14.8	80	108	78	81
3	F-5	470		Aug. 29, 1938	14.6	14.9	14.3	14.5	79	105	79	83
4	F-7	505		Aug. 31, 1938	14.8	16.0	14.4	15.0	80	100	72	76
5	F-7	505		Sept. 29, 1938	14.5	14.9	14.3	14.6	64	77	62	65
6	H-1	502	June 29, 1936	July 11, 1936	12.8	15.0	12.2	-----	100	109	94	97
7	H-1	502		July 24, 1936	12.0	14.4	11.8	-----	96	101	98	100
8	H-1	502		Aug. 18, 1936	12.3	-----	11.9	-----	90	93	94	99
9	H-2	440		July 10, 1936	13.1	15.2	13.2	-----	96	111	97	101
10	H-2	440		July 24, 1936	12.4	14.0	12.6	-----	94	102	96	97
11	H-2	440		Aug. 18, 1936	12.1	-----	11.9	-----	91	102	93	100
12	H-3	560		July 11, 1936	13.1	16.2	12.0	-----	91	108	93	95
13	H-3	560		July 25, 1936	11.6	13.2	12.0	-----	91	93	95	99
14	H-3	560		Aug. 19, 1936	11.4	-----	11.4	-----	88	96	87	89
15	H-4	424		July 12, 1936	13.7	15.6	12.4	-----	98	109	99	100
16	H-4	424		July 25, 1936	12.5	13.8	12.4	-----	95	100	96	98
17	H-4	424		Aug. 18, 1936	12.5	-----	12.3	-----	91	96	92	93
18	H-6	739	June 26, 1936	July 13, 1936	12.2	15.4	11.8	-----	84	90	90	93
19	H-6	739		Aug. 20, 1936	11.4	-----	11.4	-----	89	95	85	95
20	H-7	780		July 13, 1936	13.1	15.2	12.3	-----	96	105	97	100
21	H-7	780		Aug. 20, 1936	12.4	-----	12.5	-----	93	96	89	91
22	H-1-E	230	June 30, 1937	July 16, 1937	14.6	-----	14.9	-----	101	117	89	91
23	H-3-W	250		Aug. 19, 1937	14.9	-----	14.0	-----	92	107	86	88
24	H-4-W	260		Aug. 18, 1937	14.6	16.5	13.9	-----	90	104	83	85
25	H-4-E	230		July 17, 1937	15.1	-----	14.9	-----	94	112	86	88
26	H-10	64		July 16, 1937	15.5	-----	15.5	-----	98	110	95	95
27	H-11	96		July 20, 1937	14.9	-----	14.6	-----	104	119	86	87
28	H-12	128		July 19, 1937	14.8	-----	15.2	-----	102	120	100	100
29	U-1	298	July 2, 1936	July 21, 1936	15.7	-----	15.0	-----	92	120	88	92
30	U-1	298		July 31, 1936	15.2	-----	14.2	-----	84	100	85	86

See footnotes at end of table.

and average condition of air, at places where these investigations were conducted

Wheat—Continued				Air condition [2]					
Test weight		Wheat odor							
Before moving	After moving	Before moving	After moving	Temperature	Relative humidity	Wind velocity	Sky	Time wheat was out of bin	Remarks
Lb.	*Lb.*			°F.	*Pct.*				
55.6	56.1	Smutty	Fumigant	62	65	Medium	Cloudy	2 days	Wheat moved by portable elevator to transfer bin, at rate of approximately 200 bushels per hour and then returned to original bin by elevator to 40-foot height and run down 4-inch pipe at rate of 100 bushels per hour.
57.3	57.8	Natural	Natural	75	56	do	Clear	3 days	
55.4	55.8	Musty	Fumigant	76	55	Low	Cloudy	2 days	
55.3	56.6	do	Musty	60	65		Clear	1½ days	
56.7	57.0	do	do	75	54	Medium	Cloudy	7 days	
54.4	55.3	(3)	Natural	100	20	18 m. p. h.	Clear	1 day	Wheat moved to transfer bin by small conveyor belt, and from transfer bin back to original bin by vertical bucket elevator.
53.8	55.3	(3)	do	115	8	8 m. p. h.	do	4 hours	
55.3	55.6	Sour	Sour	95	30	7 m. p. h.	do	5 hours	
54.0	55.0	(3)	Natural	102	22	24 m. p. h.	do	1 day	
53.9	54.8	(3)	do	105	12	8 m. p. h.	do	5 hours	
55.5	55.7	Sour	Sour	100	20	7 m. p. h.	do	7 hours	
55.0	56.0	(3)	Natural	95	30	14 m. p. h.	do	5 hours	
55.8	55.7	(3)	do	104	15	9 m. p. h.	do	3 hours	
55.7	55.7	Sour	Sour	96	30	4 m. p. h.	do	1 day	
54.0	55.5	(3)	Natural	98	40	10 m. p. h.	Partly cloudy	8 hours	
54.0	55.0	(3)	do	92	30	7 m. p. h.	Clear	9 hours	
55.0	55.1	Sour	Sour	105	18	7 m. p. h.		1 day	
54.7	56.2	(3)	Natural	103	22	5 m. p. h.	Clear	do	
56.2	56.2	Sour	Sour	75	56	1 m. p. h.	do	do	
55.0	56.7	(3)	Natural	92	45	5 m. p. h.	do	6 hours	
55.6	56.2	Sour	Sour	80	60	1 m. p. h.	do	4 hours	
59.3	60.0	Musty	Musty	78	70	6 m. p. h.	Partly cloudy	1 day	
56.4	59.4	do	do	79	62	5 m. p. h.	do	do	
57.9	59.4	do	do	80	59	5 m. p. h.	do	do	
58.0	59.8	do	do	84	51			1½ days	
58.2	59.0	do	do	86	61	9 m. p. h.	Partly cloudy	3 hours	Wheat shoveled onto canvas on ground, and then shoveled back into bin.
59.0	59.3	do	do	82	56	4 m. p. h.	Clear	1 day	Wheat run into transfer bin, left there overnight and then returned to original bin via elevator.
59.4	58.8	do	do	78	65	6 m. p. h.	do	5 hours	Wheat shoveled onto canvas on ground, and then shoveled back into bin.
----	----			77	39	4 m. p. h.	Partly cloudy	1½ days	Wheat was scooped into trucks, wagons, and elevator hopper, allowed to stand overnight, and then returned to bin through elevator.
----	60.0	Musty	Natural	76	44	5 m. p. h.	Clear	3 days	Wheat scooped to large canvas on ground, piled to depth of 18 inches. Every 4 hours 4 inches removed from pile on canvas and returned to bin via elevator.

TABLE 33.—*Summary of wheat condition before and after moving by various methods*, Continued

Test No.	Bin No.[1]	Amount of wheat	Date of original filling	Date when moved	Wheat: Moisture content: Before moving: Average	Wheat: Moisture content: Before moving: Maximum	Wheat: Moisture content: After moving: Average	Wheat: Moisture content: After moving: Maximum	Wheat: Temperature: Before moving: Average	Wheat: Temperature: Before moving: Maximum	Wheat: Temperature: After moving: Average	Wheat: Temperature: After moving: Maximum
		Bu.			*Pct.*	*Pct.*	*Pct.*	*Pct.*	*° F.*	*° F.*	*° F.*	*° F.*
31	U-2	294	July 2, 1936	July 22, 1936	15.0	-----	14.8	-----	90	120	89	95
32	U-2	294		Aug. 22, 1936	14.8	-----	13.8	-----	95	110	78	90
33	U-3 nonflue	143		July 20, 1936	15.7	-----	15.3	-----	95	120	84	90
34	U-3 nonflue	143		Aug. 3, 1936	15.0	-----	14.5	-----	88	112	82	89
35	U-2	294	July 6, 1938	Aug. 19, 1940	14.4	14.9	12.1	-----	----	----	----	----
36	U-3	286	July 5, 1938	Aug. 3, 1939	15.1	16.2	13.8	-----	84	95	86	93
37	B-1	236	July 11, 1936	Aug. 7, 1936	16.2	-----	16.1	-----	98	119	94	98
38	B-1	236		Aug. 15, 1936	16.0	-----	16.0	-----	98	122	98	102
39	B-1	236		Aug. 24, 1936	15.9	-----	15.9	-----	88	120	91	104
40	B-3	228		Aug. 11, 1936	16.1	-----	16.1	-----	95	117	93	101
41	B-3	228		Aug. 19, 1936	16.2	-----	16.2	-----	98	116	96	98
42	B-4	209		Aug. 10, 1936	16.2	-----	16.1	-----	99	119	98	102
43	B-4	209		Aug. 18, 1936	16.1	-----	16.1	-----	102	121	97	103
44	B-7	271		Aug. 13, 1936	16.4	-----	16.4	-----	91	118	97	102
45	B-7	271		Aug. 20, 1936	16.4	-----	16.4	-----	94	115	93	100

[1] Bin prefix letter indicates location of bin: F—Fargo, N. Dak.; H—Hays, Kans; U—Urbana, Ill.; and B—College Park, Md.

and average condition of air, at places where these investigations were conducted—

Wheat—Continued				Air condition [2]					
Test weight		Wheat odor							
Before moving	After moving	Before moving	After moving	Temperature	Relative humidity	Wind velocity	Sky	Time wheat was out of bin	Remarks
Lb.	*Lb.*			° F.	*Pct.*				
----	----	----------	----------	82	38	5 m. p. h.	do	1 day	Wheat was scooped into trucks, wagons, and elevator hopper, allowed to stand over night, and then returned to bin through elevator.
----	60.0	----------	Natural	81	59	8 m. p. h.	----------	9 days	Wheat scooped to large canvas on ground, piled to depth of 18 inches. Every 4 hours 4 inches removed from pile on canvas and returned to bin via elevator.
----	----	----------	----------	78	48	6 m. p. h.	Cloudy	1 day	Wheat was scooped into trucks, wagons, and elevator hopper, allowed to stand overnight, and then returned to bin through elevator.
----	59.6	----------	Natural	76	61	4 m. p. h.	Partly cloudy	7 days	
58.0	58.9	Musty	Musty	----	----	----------	----------	4 days	Wheat scooped to large canvas on ground, piled to depth of 18 inches Every 4 hours 4 inches removed from pile on canvas and returned to bin via elevator.
57.9	58.4	do	do	----	----	----------	----------	3 hours	Wheat removed from bin, run through fanning mill, and returned to bin.
54.7	56.2	Sour	Sour	75	63	Light	Cloudy	6 hours	Wheat scooped to canvas in sun, allowed to dry, and then shoveled back into bin.
54.3	54.4	do	do	84	71	Fresh	Clear	do	
54.2	54.2	do	do	87	53	Light	do	do	
56.3	56.4	do	do	77	71	do	do	do	
55.2	55.2	do	do	83	66	Fresh	do	do	
56.0	56.3	do	do	88	46	Light	do	do	
55.3	55.3	do	do	85	31	Fresh	do	do	
56.8	56.8	do	do	92	40	Light	do	do	
55.2	55.2	do	do	82	72	do	do	do	

[2] Average for entire moving operation, until wheat was back in original bin.
[3] Wheat heating and musty in parts of bin only.

SUMMARY AND CONCLUSIONS

Various measurements were used to determine the quality of the wheat during the storage period. The external evidences of wheat deterioration (such as percent total damage, test weight, odor, etc.) usually were not apparent until the condition of the grain had been lowered enough to affect its commercial grade. However, percent germination and fat acidity of sound wheat were found to be valuable indices of incipient deterioration that is not apparent from grade examination, and graphs are presented to show the relation of percent total damage and percent germination to fat acidity through the range from 10 to 40 units of fat acidity. Few samples were obtained having a fat acidity below 10 units and at a fat acidity of 40 units the grain ordinarily had developed an abnormal odor.

In determining the maximum wheat moisture content for safe storage in any given area, consideration must be given to the length of time the wheat is to be stored, the size and type of bin, and the initial condition of the wheat. At Fargo, 500-bushels of wheat with an initial moisture content of 14.2 percent was stored for over 1,200 days in an unventilated metal bin before the entire lot turned musty, although at 664 days of storage a small portion, amounting to 4 or 5 bushels, had an abnormal odor. Wheat with a moisture content of 14.5 percent stored safely for over 400 days in 500 bushel lots, but developed an abnormal odor shortly thereafter. The wheat in the above tests was well mixed and had a very uniform moisture content. In tests with combined wheat, where the wheat moisture content was uneven, it was found that the length of safe storage did not depend upon the average moisture content for the bin but upon the highest wheat moisture content in the bin. Thus, a 500-bushel bin of wheat having an average moisture content of 13.7 percent developed an abnormal odor in a portion having a high moisture content in only 38 days. By removing small spoiled portions when first found, and by thoroughly mixing the wheat so as to break up pockets of high moisture wheat the length of safe storage in North Dakota can usually be increased over that observed in these investigations. In unventilated bins, where there is no air movement through the wheat, moisture does not equalize throughout the bin and deterioration proceeds at a more rapid rate in the damp areas than in the dry.

The maximum moisture content safe for storage in Kansas differs widely from that for North Dakota, probably because of the higher air temperatures prevailing, both during and after harvest. At Hays, storage of wheat in unventilated bins at an average moisture content over 12.5 percent is not safe if there is any possibility of the wheat being of uneven moisture content. However, wheat with a uniform average moisture content of 11.6 percent was stored safely in a 1,000-bushel metal bin for 4½ years, but the first 2 years of the storage period the wheat was in a bin having a perforated floor.

In the tests at College Park, wheat with a uniform moisture content of 16.4 percent, stored in 250-bushel lots, heated and quickly went out of condition, while wheat of 14.2 percent moisture stored safely for about 9 months, or until the air temperature began to warm up in the spring following storage. Wheat of 13.3 percent uniform moisture content was stored safely in a 400-bushel plywood bin on the north side of a granary, for a period of over 900 days, although at the end of that

time the wheat at the center of the bin had lost all viability and had a very high fat acidity.

At Urbana, all wheat of 14.7 percent moisture content went out of condition after 2 months' storage, and the tests indicated that for 1 year of safe storage the maximum moisture content cannot be over 14.2 percent.

Plain metal bins, metal bins insulated with 3 inches of glass or rock wool, and shaded metal bins of 20-bushel capacity were filled with wheat of various moisture contents at each of the experimental stations, and where possible, the changes in quality of the wheat during storage were compared with changes in similar wheat stored in full-size bins. Without exception the wheat in the small bins remained in storage for a longer period before developing an abnormal odor than in the full-size unventilated bins. The small bins also in general showed a much larger variation in moisture content during the storage period—at Fargo an increase over that in the large bins because of absorption of moisture from the high humidity winter air and from snow blowing in at the eaves, and at the other stations a decrease because of the shallower depth of wheat than in the large bin. At Urbana, however, small shaded bins showed a slight increase in moisture content. At all stations the variation of moisture content within the small bins during the storage period was less in the shaded and insulated bins than in the plain metal bins. At Fargo and Urbana the rate of wheat deterioration was slightly less in the insulated bins than in the plain metal bins while at College Park the insulation apparently had the opposite effect. In general, the wheat in the small shaded bins was stored in slightly better condition than in the plain metal bins.

Ventilated bins at all stations safely stored wheat at a higher moisture content than could be stored in an unventilated bin of the same size. At Fargo a ventilated bin having a wind pressure cowl forcing air into a central drum and through the wheat to the perforated bin walls and floor and the upper wheat surface was more effective in storing wheat with an initial moisture content of 15.8 percent than were unventilated bins in storing 14.2 and 14.5 percent wheat. Final spoilage of the wheat was caused by snow entering the duct system. A bin ventilated by horizontal screen covered flues also safely stored wheat with an initial moisture content of 15.6 percent for a longer period than the wind pressure cowl ventilated bin because no snow entered the flues, although the initial rate of drying was slower. Power ventilated bins, using silo filler and grain elevator blowers quickly reduced the moisture content of 15.8 percent wheat to a safe level at Fargo. As with unventilated bins, wheat of uneven moisture content provides an extra storage hazard and in bins not using some sort of wind pressure or power ventilation system, as in the bins having only horizontal flues open to the air at the ends, the wheat must be mixed thoroughly before storage.

At Hays, no bin using natural ventilation, or not using some sort of power ventilation, successfully stored wheat with a moisture content of over 15 percent for more than 80 days. However, several power ventilated bins quickly dried wheat of 16 percent moisture content to a safe level and in a favorable year would probably successfully store wheat of even higher moisture content. In Kansas a ventilated bin,

to be successful, must reduce the wheat to a moisture content of about 12 percent in the first month of storage.

The weather conditions at College Park differ from those at the other stations in that the relative humidity is higher during the summer than during the winter (fig. 23), in contrast to the usual low relative humidity during the summer and fall months at Fargo, Hays, and Urbana (figs. 16, 19, and 26). However, conditions for drying at College Park during the winter are relatively favorable, and if wheat can be kept from heating until cool weather it can be dried out slowly in ventilated bins before the next warm season. Horizontal flues spaced 24 inches on center did not prevent heating of 16.4 percent wheat, but by placing the flues closer together, increasing their area, and utilizing pressure and suction cowls to force air through the grain, wheat of 15.1 percent initial moisture content was stored safely for over 3½ years. During this period no abnormal odor developed although there was a large decrease in germination and increase in fat acidity. Forced ventilation during the driest part of the day and where the air path through the wheat was only about 2 feet, was also satisfactory but might not be dependable in seasons of higher relative humidity.

Horizontal flues in bins at Urbana retarded heating of wheat containing 15.5 percent of moisture but did not prevent eventual damage. Vertical flues connected to a suction cowl removed little moisture from 14.7 percent wheat but because of the cooling effect safely stored such wheat for 10 times as long a period as was observed in unventilated bins. Power-ventilated bins, in which both normal and heated air were forced up through 6 feet of wheat, were not successful at Urbana, although where the air path was reduced to 3 feet, wheat of 16 percent moisture content was dried to a safe level before much damage occurred.

In tests of underground bins at Hays and Urbana it was found that the greatest hazards to safe storage are accumulation of moisture near the bin walls and the slow cooling of the grain when placed in storage at a temperature higher than that of the ground. When the wheat was cooled quickly by ventilation and precautions against accumulation of moisture at the walls taken, grain stored with less deterioration and for longer periods of time than did wheat of similar average moisture content stored above ground.

The use of admixtures in stored wheat as fungicides, insecticides and absorbents, was studied in both large and small bins. Lime-and-sulfur mixture as a fungicide was of some value in extending the storage period of wheat before the development of abnormal odors, but caused a decrease in test weight which in several cases was great enough to lower the numerical grade. Another fungicide, a 1 : 1 formalin-water solution applied at the rate of one-half pint for 22 bushels of wheat, was not beneficial in prolonging the safe storage period but caused no lowering in test weight. In further tests higher concentrations may be of value.

A pyrethrum compound at the concentration and dosage used as an insecticide in bins at Urbana did not prevent the appearance of insects.

Straw, both chopped, unchopped, and in bags, peat, and whole and ground oats were mixed with damp wheat to test their efficiency as absorbents. Straw was not effective unless chopped to short lengths and distributed evenly through the wheat. At the rate of 2 pounds of chopped straw per bushel of wheat, 15.5 percent wheat was reduced 0.6 percent in moisture content. Peat moss absorbed moisture from the wheat but did not in all cases prevent spoilage. Whole oats, with an initial moisture content of 10.7 percent, when mixed with wheat of 15.6 percent moisture content at the rate of 189 bushels of oats to 350 bushels of wheat reduced the wheat moisture content 0.6 percent. Other absorbents, such as broken tile and brick, logs and posts, and soda were found to have little value as drying agents.

Moving and turning wheat by means of portable farm elevators or by shoveling is of little value in reducing the average wheat moisture content, although much benefit may be derived from the mixing of damp wheat with dry wheat placed in the same bin, if the operation is undertaken before heating occurs. Similarly, little cooling of hot wheat is effected by turning unless the air temperature is well below the wheat temperature, although here again mixing of hot and cool portions will lower the maximum wheat temperature.

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APPENDIX

Tabular Data

Tables 34 to 45 inclusive contain information on bin types and construction, and on the initial and final quality of the wheat observed in the various bins during the investigation.

Table 34.—*Description of experimental bins filled at Fargo in 1936, 1937, 1938, and 1939*

BINS FILLED IN 1936

Bin No.	Location of bin	Roof type	Bin surfaces contacting wheat				Bulk aeration			Bulk measurements		
			Floor—material	Walls			Type	Air paths through bulk		Quantity	Average depth	Half minimum width
				Material	Number exposed to sun	Resistance to heat transfer [1]		Average	Range			
								Feet	*Feet*	*Bushels*	*Feet*	*Feet*
F-1	Outdoors	Metal	Metal	Metal	3	0.7	None	0	0	493	8.0	7.0
F-2	Outdoors	do	Concrete	do	3	.7	do	0	0	493	8.0	7.0
F-3	Outdoors	Insulated metal	Wood	Wallboard lining	0	3.12	do	0	0	471	8.0	6.8
F-4	Outdoors	do	do	do	0	3.12	do	0	0	477	8.0	6.8
F-5	Outdoors	Metal	Perforated metal	Perforated metal	3	.7	Wall and bottom surface.	7.5	8.0	493	8.0	7.0
F-6	Outdoors	do	do	do	3	.7	do	7.5	8.0	493	8.0	7.0
F-7	Outdoors	do	Metal	Metal	3	.7	Ducts	2.5	5.5	482	8.0	7.0
F-8	Outdoors	do	Perforated metal	do	3	.7	Forced (wind)	8.0	0	493	8.0	7.0
F-9	Outdoors	Roll	Wood	Wood	3	1.68	Ducts	2.5	6.3	525	8.0	6.0
F-10	Outdoors	do	do	do	3	1.68	do	4.0	8.0	526	8.0	6.0
F-11	Outdoors	do	do	do	3	3.57	do	2.5	6.3	446	8.0	6.0
F-12	Outdoors	do	do	do	3	3.57	None	0	0	458	8.0	6.0
F-26	Outdoors	Metal	Metal	Metal	(2)	.7	do	0	0	20	3.0	1.6
F-27	Outdoors	Wallboard	Insulated metal	Insulated metal	(2)	10.69	do	0	0	20	3.0	1.6
F-28	Outdoors	Metal	Metal	Metal	(2)	.7	do	0	0	20	3.0	1.6
F-29	Outdoors	Wallboard	Insulated metal	Insulated metal	(2)	10.69	do	0	0	20	3.0	1.6
F-30	Outdoors	Metal	Metal	Metal	(2)	.7	do	0	0	20	3.0	1.6
F-31	Outdoors	Wallboard	Insulated metal	Insulated metal	(2)	10.69	do	0	0	20	3.0	1.6
F-32	Outdoors	Metal	Metal	Metal	(2)	.7	do	0	0	20	3.0	1.6
F-33	Outdoors	Wallboard	Insulated metal	Insulated metal	(2)	10.69	do	0	0	20	3.0	1.6
F-34	Outdoors	Metal	Metal	Metal	(2)	.7	do	0	0	15	3.0	1.6
F-35	Outdoors	Wallboard	Insulated metal	Insulated metal	(2)	10.69	do	0	0	15	3.0	1.6

BINS FILLED IN 1937

F-1	Outdoors	Metal	Metal	Metal	3	0.7	None	0	0	500	8.0	7.0
F-2		do	Concrete	do	3	.7	do	0	0	500	8.0	7.0
F-3		do	Wood	do	3	.7	do	0	0	462	7.5	7.0
F-4		do	do	do	3	.7	do	0	0	500	8.0	7.0
F-5		do	Perforated metal	Perforated metal	3	.7	Power	3.8	1.2	477	8.0	1.8
F-6		do	do	do	3	.7	Forced (wind)	3.8	1.2	477	8.0	1.8
F-7		do	Metal	Metal	3	.7	Ducts	2.5	5.5	482	8.0	7.0
F-8		do	Perforated metal	do	3	.7	Forced (wind)	5.2	0	350	5.2	7.0
F-9		Roll	Wood	Wood	3	1.68	do	1.0	.2	400	8.0	6.0
F-10		do	do	do	3	1.68	None	0	0	500	7.9	6.0
F-11		do	do	do	3	3.57	Ducts	2.5	6.0	500	8.0	6.0
F-12		do	do	do	3	3.57	None	0	0	500	8.0	6.0
F-28		Metal	Metal	Metal	(2)	.7	do	0	0	20	3.0	1.6
F-29		Wallboard	Insulated metal	Insulated metal	(2)	10.69	do	0	0	20	3.0	1.6
F-30		Metal	Metal	Metal	(2)	.7	do	0	0	20	3.0	1.6
F-31		Wallboard	Insulated metal	Insulated metal	(2)	10.69	do	0	0	20	3.0	1.6
F-32		Metal	Metal	Metal	(2)	.7	do	0	0	20	3.0	1.6
F-33		Wallboard	Insulated metal	Insulated metal	(2)	10.69	do	0	0	20	3.0	1.6
F-34		Metal	Metal	Metal	(2)	.7	do	0	0	20	3.0	1.6
F-35		Wallboard	Insulated metal	Insulated metal	(2)	10.69	do	0	0	20	3.0	1.6
F-36		Metal	Metal	Metal	(2)	.7	do	0	0	16	2.0	1.6
F-37		do	do	do	(2)	.7	do	0	0	16	2.5	1.6
F-38		do	do	do	(2)	.7	Forced (wind)	3.0	1.3	20	3.0	1.6
F-39		do	Straw-lined metal	do	(2)	.7	None	0	0	17	2.5	1.6

BINS FILLED IN 1938

F-3	Outdoors	Metal	Wood	Metal	3	0.7	None	0	0	450	7.0	7.0
F-4		do	do	do	3	.7	do	0	0	440	7.0	7.0
F-5		do	Perforated metal	Perforated metal	3	.7	Bottom and wall surface.	7.5	10.2	470	7.5	7.0
F-7		do	Metal	Metal	3	.7	Ducts	2.5	5.5	595	7.9	7.0
F-8		do	Perforated metal	do	3	.7	Power	3.5	1.4	495	7.6	1.8
F-9		Roll	Wood and screen	Wood	3	1.69	do	7.9	.9	505	7.5	6.0
F-26	3-sided shed	Metal	Metal	Metal	(3)	.7	None	0	0	18	2.6	1.6
F-27	Outdoors	do	do	do	(2)	.7	do	0	0	18	2.6	1.6
F-28		do	do	do	(2)	.7	do	0	0	20	3.0	1.6
F-29		Wallboard	Insulated metal	Insulated metal	(2)	10.69	do	0	0	20	3.0	1.6
F-36		Metal	Metal	Metal	(2)	.7	do	0	0	20	3.0	1.6
F-37		do	do	do	(2)	.7	do	0	0	20	3.0	1.6
F-38		do	do	do	(2)	.7	Forced (wind)	2.9	.5	20	3.0	1.6
F-39		do	Straw-lined metal	do	(2)	.7	None	0	0	17	2.5	1.6

BINS FILLED IN 1939

F-3	Outdoors	Metal	Wood	Metal	3	9.7	None	0	0	450	7.0	7.0
F-28		do	Metal	do	(2)	.7	Restricted [4]			20	3.0	1.6
F-36		do	do	Shaded metal	0	.7	None	0	0	20	3.0	1.6

[1] Resistance or degrees Fahrenheit difference in temperature on opposite surfaces of wall which will cause 1 B. t. u. of heat to pass through an area of 1 square foot in 1 hour.
[2] All walls supporting wheat exposed to sun.
[3] Parts of three walls exposed to sun.
[4] Opening at eaves closed by means of pressing the roof down upon a rubber gasket.

TABLE 35.—*Condition and quality of wheat, harvest method, admixtures, variations bins at Fargo, in 1936,*

Storage period when sampled (days)[1]	Portion of bulk sampled	Official grade of sample [2]	Moisture content	Test weight per bushel	Weight per 1,000 kernels	Dockage	Total damaged kernels	Normal germination	Fat Acidity [3]	Odor	Fumigated	Weevil and other insect infestation
			Pct.	*Lb.*	*Gm.*	*Pct.*	*Pct.*	*Pct.*	*Units*			
BIN F-1, FILLED												
0	Average	4, Tough	15.1	54.7	20.3	1.8	3.5	69	11	Natural	No	None
35	do	Sample, Tough	14.6	53.0		1.8	4.0	39	21	Musty	No	Weevils
35+35	do	do	14.7	54.5		1.8	6.8	35		Sour	Yes	None
BIN F-2, FILLED												
0	Average	4, Tough	15.0	54.8	20.3	2.0	5.3	70	16	Natural	No	None
36	do	Sample	14.5	53.5		2.0	8.0	50	19	Sour	No	Weevils
36+34	do	Sample, Tough	14.6	55.0		1.6	4.0	43		do	Yes	None
BIN F-3, FILLED												
0	Average	3, Tough	15.0	55.0	20.4	1.5	3.3	72	17	Natural	No	None
42	do	Sample	14.2	53.8		1.7	6.3	40	19	Sour	No	Weevils
42+28	do	do	14.3	55.0		1.4	5.0	44		do	Yes	None
BIN F-4, FILLED												
0	Average	3, Tough	15.0	55.1	20.4	1.5	1.8	72	16	Natural	No	None
42	do	Sample	13.8	54.5		1.5				Sour	No	Weevils
52	do	do	14.2	54.3		1.5	8.0	48	19	do	Yes	None
52+22	do	do	14.3	55.0		1.4	6.4	42		do	Yes	do
BIN F-5, FILLED												
0	Average	3, Tough	15.1	55.0	20.2	1.5	2.0	70	17	Natural	No	None
42	do	Sample	14.2	54.2		2.0				Sour	No	Weevils
53	do	do	14.5	54.4		1.8	4.2	53	17	do	Yes	None
53+21	do	do	14.2	55.1		1.5	6.2	47		do	Yes	do
BIN F-6, FILLED												
0	Average	3, Tough	14.7	55.3	20.4	1.4	5.0	68	17	Natural	No	None
42	do	3	14.1	55.0		1.7				do	No	Insects
56	do	Sample, Tough	14.6	55.0		1.6				Sour	Yes	None
71	do	Sample	14.2	54.6		1.7	5.4	49	22	do	Yes	do

See footnotes at end of table.

in quality throughout bin and temperature data of wheat stored in experimental 1937, 1938, and 1939

AUG. 31, 1936

Variations shown in other portions of bulk at same storage period								Admixtures	Harvest method or source of wheat	First "maximum temperature period" in center of bulk [1]				Remarks
Moisture		Normal germination		Fat acidity [3]		Total damaged kernels				Initial temperature	"Final" temperature	Average temperature	Length of period	
Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum							
Pct.	*Pct.*	*Pct.*	*Pct.*	*Units*	*Units*	*Pct.*	*Pct.*			*°F.*	*°F.*	*°F.*	*Dy.*	
								None	Commercial (wetted).	76	96	85.0	26	Trace of mold, germ damaged.
17.7	14.5	41	4	55		6.8	3.0	do	do	76	96	85.0	26	
								do	do	76	96	85.0	26	Heating, musty and becoming caked.

AUG. 31, 1936

								None	Commercial (wetted).	74	81	78.0	28	Trace of mold, germ damaged.
15.6	14.1	58	6	40		10.0	6.0	do	do	74	81	78.0	28	
								do	do	74	81	78.0	28	Heating, musty and becoming caked.

AUG. 31, 1936

								None	Commercial (wetted).	76	88	82.5	33	Trace of mold, germ damaged.
16.0	14.1	59	8	25		13.7	5.0	do	do	76	88	82.5	33	
								do	do	76	88	82.5	33	Heating and musty.

AUG. 31, 1936

								None	Commercial (wetted).	72	78	75.5	23	Trace of green kernels and germ damage.
15.8								do	do	72	78	75.5	23	Top and center portion musty and heating.
16.9		55	7	44		17.0	6.0	do	do	72	78	75.5	23	
								do	do	72	78	75.5	23	Top and center portion warm and musty.

AUG. 31, 1936

								None	Commercial (wetted).	77	80	78.9	21	Trace of green kernels and germ damage.
15.6								do	do	77	80	78.9	21	Top and center portion sour.
17.1	14.2	62	11	45		19.0		do	do	77	80	78.9	21	Top and center portion musty.
								do	do	77	80	78.9	21	

AUG. 31, 1936

								None	Commercial (wetted).	72	74	73.0	9	Moldy and germ damaged.
15.4								do	do	72	74	73.0	9	Top and center portion sour.
15.3	14.1							do	do	72	74	73.0	9	
								do	do	72	74	73.0	9	Moldy and germ damaged.

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TABLE 35.—*Condition and quality of wheat, harvest method, admixtures, variations bins at Fargo, in 1936, 1937,*

Storage period when sampled (days) [1]	Portion of bulk sampled	Official grade of sample [2]	Moisture content	Test weight per bushel	Weight per 1,000 kernels	Dockage	Total damaged kernels	Normal germination	Fat acidity [3]	Odor	Fumigated	Weevil and other insect infestation
			Pct.	*Lb.*	*Gm.*	*Pct.*	*Pct.*	*Pct.*	*Units*			
BIN F-7, FILLED												
0	Average	3, Tough	15.0	55.0	20.4	2.0	5.3	65	18	Natural	No	None
49	do	Sample	14.2	54.8		1.9				Sour	Yes	do
72	do	do	14.4	54.6		1.8	5.0	44	21	do	Yes	do
BIN F-8, FILLED												
0	Average	3, Tough	15.0	55.0	20.3	1.9	3.4	76	18	Natural	No	None
49	do	4	14.3	54.3		1.6				do	Yes	do
61	do	4	14.2	54.0		1.7	4.6	46	23	do	Yes	Weevils
61+11	do	Sample	14.3	55.2	20.5	1.5	4.0	43		Sour	Yes	None
BIN F-9, FILLED												
0	Average	4, Tough	15.1	54.5	20.2	2.0	2.3	70	17	Natural	No	None
49	do	Sample	14.5	54.6		1.8				Sour	Yes	do
73	do	do	15.9	54.8		2.0	7.0	71	19	do	Yes	do
BIN F-10, FILLED												
0	Average	4, Tough	15.1	54.5	20.5	2.4	2.7	68	18	Natural	No	None
42	do	Sample	14.5	54.0		2.3				Sour	No	Insects
57	do	do	14.7	53.8		2.4	5.6	48	18	do	Yes	None
57+16	do	do	14.4	54.7		1.9	6.0	52		do	Yes	do
BIN F-11, FILLED												
0	Average	3, Tough	15.1	55.1	20.2	1.3	3.2	67	12	Natural	No	None
59	do	Sample	14.3	54.7		1.7				Sour	Yes	do
73	do	do	14.2	54.6		1.9	6.7	48	20	do	Yes	do
BIN F-12, FILLED												
0	Average	3, Tough	14.9	55.5	20.2	1.5	3.6	72	17	Natural	No	None
37	do	Sample, Tough	14.8	52.8		1.8	2.6	37		Sour	No	Weevils
37+36	do	do	14.8	55.0		1.2	6.0	31		do	Yes	None

See footnotes at end of table.

in quality throughout bin and temperature data of wheat stored in experimental 1938, and 1939—Continued

Variations shown in other portions of bulk at same storage period								Admixtures	Harvest method or source of wheat	First "maximum" temperature period" in center of bulk [4]				Remarks
Moisture		Normal germination		Fat acidity [3]		Total damaged kernels				Initial temperature	"Final" temperature	Average temperature	Length of period	
Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum							
Pct.	*Pct.*	*Pct.*	*Pct.*	*Units*	*Units*	*Pct.*	*Pct.*			°*F.*	°*F.*	°*F.*	*Dy.*	
AUG. 31, 1936														
----	----	----	----	----	----	----	----	None	Commercial (wetted).	74	76	74.5	5	Germ damage and trace of green kernels.
----	----	----	----	----	----	----	----	do	do	74	76	74.5	5	
----	----	----	----	----	----	----	----	do	do	74	76	74.5	5	
AUG. 31, 1936														
----	----	----	----	----	----	----	----	None	Commercial (wetted).	75	76	75.2	12	Germ damage and trace of green kernels.
17.0	----	----	----	----	----	----	----	do	do	75	76	75.2	12	Top portion sour.
17.4	13.7	60	3	40	----	11.0	1.6	do	do	75	76	75.2	12	
----	----	----	----	----	----	----	----	do	do	75	76	75.2	12	
AUG. 31, 1936														
----	----	----	----	----	----	----	----	None	Commercial (wetted).	72	73	71.9	8	Germ damage and trace of green kernels.
----	----	----	----	----	----	----	----	do	do	72	73	71.9	8	
----	----	----	----	----	----	----	----	do	do	72	73	71.9	8	
AUG. 31, 1936														
----	----	----	----	----	----	----	----	None	Commercial (wetted).	77	85	80.8	18	Germ damage and trace of green kernels.
----	----	----	----	----	----	----	----	do	do	77	85	80.8	18	
15.3	14.6	59	22	25	----	----	5.0	do	do	77	85	80.8	18	Center portion musty. Balance natural odor.
----	----	----	----	----	----	----	----	do	do	77	85	80.8	18	
AUG. 31, 1936														
----	----	----	----	----	----	----	----	None	Commercial (wetted).	75	76	75.5	12	Trace of green and immature kernels and germ damage.
15.0	13.8	----	----	----	----	----	----	do	do	75	76	75.5	12	
15.1	14.1	56	47	----	18	10.7	5.5	do	do	75	76	75.5	12	Center portion musty. Balance portion sour.
AUG. 31, 1936														
----	----	----	----	----	----	----	----	None	Commercial (wetted).	75	84	79.8	26	Trace of green kernels and germ damage.
17.0	14.4	62	10	55	----	6.3	1.7	do	do	75	84	79.8	26	
----	----	----	----	----	----	----	----	do	do	75	84	79.8	26	Top and center portion musty and heating.

TABLE 35.—*Condition and quality of wheat, harvest method, admixtures, variations bins at Fargo, in 1936, 1937,*

Storage period when sampled (days)[1]	Portion of bulk sampled	Official grade of sample [2]	Moisture content	Test weight per bushel	Weight per 1,000 kernels	Dockage	Total damaged kernels	Normal germination	Fat Acidity [3]	Odor	Fumigated	Weevil and other insect infestation
			Pct.	*Lb.*	*Gm.*	*Pct.*	*Pct.*	*Pct.*	*Units*			
BIN F-26, FILLED												
1	Average	Sample	14.5	51.7	-----	1.0	1.8	64	------	Sour	No	None
347	do	Sample, Tough	15.2	49.7	18.7	1.0	10.0	8	51	Musty	No	do
720	do	Sample	13.5	50.2	16.1	.8	3.8	6	57	do	No	do
BIN F-27, FILLED												
1	Average	Sample	14.2	51.3	-----	1.3	1.6	49	------	Sour	No	None
347	do	5, Tough	15.0	50.3	18.1	1.1	6.0	13	43	Natural	No	do
720	do	Sample	14.1	50.3	16.2	1.1	10.0	1	49	Musty	No	do
BIN F-28, FILLED												
1	Average	Sample, Tough	15.0	51.5	-----	1.2	1.4	57	------	Sour	No	None
328	Bottom layer	Sample	16.9	46.3	17.3	1.5	12.0	4	56	Musty	No	do
BIN F-29, FILLED												
1	Average	Sample, Tough	15.0	51.1	-----	1.2	1.6	59	------	Sour	No	None
349	do	do	15.7	49.3	18.5	1.3	6.5	10	56	Musty	No	do
BIN F-30, FILLED												
1	Average	Sample	14.5	52.1	-----	.8	3.3	57	------	Sour	No	None
346	Top layer	do	13.9	49.7	18.3	1.0	6.0	16	------	Musty	No	do
BIN F-31, FILLED												
1	Average	Sample	14.5	51.8	-----	.8	2.3	44	------	Sour	No	None
346	do	Sample, Tough	15.6	50.0	18.9	.8	8.0	9	48	Musty	No	do
BIN F-32, FILLED												
1	Average	Sample, Tough	15.8	51.3	-----	1.1	0.5	62	------	Sour	No	None
308	do	do	15.8	48.5	-----	1.1	3.0	13	------	Musty	No	do
BIN F-33, FILLED												
1	Average	Sample, Tough	15.6	50.8	-----	1.4	1.3	51	------	Sour	No	None
350	Bottom half.	Sample	18.2	46.5	18.4	1.4	14.5	0	67	Musty	No	do
BIN F-34, FILLED												
1	Average	Sample, Tough	15.4	51.1	-----	2.8	1.3	58	------	Sour	No	None
350	do	do	15.2	49.5	18.5	2.3	5.0	11	52	Musty	No	do

See footnotes at end of table.

in quality throughout bin and temperature data of wheat stored in experimental 1938, and 1939—Continued

Variations shown in other portions of bulk at same storage period								Admixtures	Harvest method or source of wheat	First "maximum" temperature period" in center of bulk [4]				Remarks
Moisture		Normal germination		Fat acidity [3]		Total damaged kernels								
Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum			Initial temperature	"Final" temperature	Average temperature	Length of period	
Pct.	*Pct.*	*Pct.*	*Pct.*	*Units*	*Units*	*Pct.*	*Pct.*			°*F.*	°*F.*	°*F.*	*Dy.*	
AUG. 6, 1936														
19.7			0	59	53			None	Commercial	83	91	87.2	8	
AUG. 6, 1936														
16.2		3	0	57				None	Commercial	84	87	86.1	11	
AUG. 5, 1936														
17.8			0	68		10.0		None do	Commercial do	73 73	95 95	86.2 86.2	10 10	Wheat in bottom 1½ inches wet, rotten; not included.
AUG. 5, 1936														
								None	Commercial	73	92	85.5	16	
AUG. 7, 1936														
16.8			3			21.0		None	Commercial	78	89	86.0	8	
AUG. 7, 1936														
								None	Commercial	82	87	85.2	14	
AUG. 3, 1936														
								None	Commercial	78	105	94.0	15	
AUG. 3, 1936														
	15.8	9			51		11.0	None do	Commercial do	78 78	107 107	94.5 94.5	18 18	Caked and musty.
AUG. 3, 1936														
								Straw	Commercial	80	107	90.8	11	

TABLE 35.—*Condition and quality of wheat, harvest method, admixtures, variations bins at Fargo, in 1936, 1937,*

Storage period when sampled (days)[1]	Portion of bulk sampled	Official grade of sample [2]	Moisture content	Test weight per bushel	Weight per 1,000 kernels	Dockage	Total damaged kernels	Normal germination	Fat Acidity [3]	Odor	Fumigated	Weevil and other insect infestation
			Pct.	*Lb.*	*Gm.*	*Pct.*	*Pct.*	*Pct.*	*Units*			
BIN F-35, FILLED												
1	Average	Sample, Tough	15.6	51.1	-----	2.7	2.0	56	-----	Sour	No	None
350	do	do	15.2	49.7	18.6	2.2	6.0	11	47	Musty	No	do
BIN F-1, FILLED												
1	Average	3	14.5	55.6	22.8	1.5	(5)	91	19	Natural	No	None
540	Inferior	Sample	16.2	51.4	-----	.8	16.0	9	44	Musty	Yes	do
563	Average	Sample, Tough	14.8	53.8	-----	1.0	.9	35	34	do	No	do
894	do	Sample	14.3	54.1	-----	.7	7.7	17	37	do	No	do
BIN F-2, FILLED												
0	Average	3	14.2	55.3	20.8	1.3	0.2	89	16	Natural	No	None
664	Inferior	Sample, Tough	14.6	54.8	-----	1.8	1.0	45	30	Musty	Yes	do
865	Average	3	13.7	55.0	-----	1.0	1.9	58	29	Natural	No	do
1,210	do	Sample	13.8	55.0	-----	.8	4.0	36	34	Musty	No	do
BIN F-3, FILLED												
1	Average	3	14.2	55.0	20.0	2.5	0.4	86	17	Natural	No	None
192	do	4	14.2	54.8	21.0	2.8	.2	84	19	do	No	do
BIN F-4, FILLED												
3	Average	4, Tough	15.0	53.5	19.1	5.0	0.2	87	18	Natural	No	None
194	do	do	15.0	53.2	19.5	4.5	.4	80	19	do	No	do
BIN F-5, FILLED												
0	Average	4, Tough	15.4	53.3	19.2	4.7	(5)	87	18	Natural	No	None
200	do	4	14.1	53.6	18.8	4.2	0.3	83	[6] 18	do	No	do

See footnotes at end of table.

in quality throughout bin and temperature data of wheat stored in experimental 1938, and 1939—Continued

variations shown in other portions of bulk at same storage period								Admixtures	Harvest method or source of wheat	First "maximum temperature period" in center of bulk [4]				Remarks
Moisture		Normal germination		Fat acidity [3]		Total damaged kernels								
Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum			Initial temperature	"Final" temperature	Average temperature	Length of period	
Pct.	*Pct.*	*Pct.*	*Pct.*	*Units*	*Units*	*Pct.*	*Pct.*			°*F.*	°*F.*	°*F.*	*Dy.*	
AUG. 3, 1936														
----	----	----	----	------	------	----	----	Straw	Commercial	78	107	94.2	18	
AUG. 16, 1937														
14.6	----	----	86	------	17	0.2	----	None	Commercial	75	82	78.0	24	
----	13.7	61	----	------	29	----	0.5	do	do	75	82	78.0	24	Inferior portion about 4 bushels at top of bin.
16.3	13.2	92	18	40	24	----	----	do	do	75	82	78.0	24	
14.6	11.5	90	1	43	26	11.5	3.3	do	do	75	82	78.0	24	
SEPT. 14, 1937														
----	13.9	90	88	16	------	----	----	None	Commercial	74	77	75.8	7	After artificial drying.
----	11.2	84	34	31	21	----	0.5	do	do	74	77	75.8	7	From musty pockets under each roof door.
15.3	12.2	83	19	31	25	4.7	.5	do	do	74	77	75.8	7	A few bran bugs found in the inferior portion at bottom of bin.
15.7	11.8	54	3	------	------	----	----	do	do	74	77	75.8	7	
SEPT. 10, 1937														
14.4	14.0	----	85	19	------	----	0.1	None	Commercial	76	76	75.5	11	Wheat dried by elevating and aerating.
15.3	13.6	88	80	------	17	0.4	.1	do	do	76	76	75.5	11	
SEPT. 8, 1937														
15.2	14.9	88	86	19	18	0.7	0.1	None	Commercial	81	76	76.0	16	Wheat dried by aerating.
15.6	14.6	82	71	21	18	----	.1	do	do	81	70	76.0	16	
SEPT. 2, 1937														
15.8	----	88	84	19	18	0.5	----	None	Commercial	84	68	64.0	32	Ventilating fan started immediately after filling bin.
15.2	----	86	----	------	14	----	(5)	do	do	84	68	64.0	32	

TABLE 35.—*Condition and quality of wheat, harvest method, admixtures, variations bins at Fargo, in 1936, 1937,*

Storage period when sampled (days) [1]	Portion of bulk sampled	Official grade of sample [2]	Moisture content	Test weight per bushel	Weight per 1,000 kernels	Dockage	Total damaged kernels	Normal germination	Fat acidity [3]	Odor	Fumigated	Weevil and other insect infestation
			Pct.	*Lb.*	*Gm.*	*Pct.*	*Pct.*	*Pct.*	*Units*			
BIN F-6, FILLED												
0	Average	4, Tough	15.8	53.1	18.7	2.6	0	88	18	Natural	No	None
736	Bottom layer.	Sample	12.9	53.8		2.6	1.0	63	30	Musty	No	do
877	Average	4	13.2	53.6		2.6	.4	65	29	Natural	No	do
1,222	do	Sample	13.2	53.0		3.8	5.0	58	36	Musty	No	do
BIN F-7, FILLED												
0	Average	5, Tough	15.6	50.7	18.3	5.1	0.5	85	17	Natural	No	None
200	do	do	15.0	51.8	17.5	4.9	.1	81	18	do	No	do
BIN F-8, FILLED												
0	Average	Mixed grain, Tough.	15.0							Natural	No	None
24+1	do	4	14.5	53.0	19.6	5.0	0.2	80	22	do	No	do
24+175	do	4	14.3	53.5	18.4	4.7	.6	85	[5] 22	do	No	do
BIN F-9, FILLED												
0	Average	4, Tough	15.6	53.7	19.8	3.0	0.1	86	18	Natural	No	None
68	do	4	14.1	53.2		3.0	.2	85	19	do	No	do
200	do	5, Tough	15.6	52.2	18.0	3.1	(4)	79	16	do	No	do
BIN F-10, FILLED												
1	Average	3	14.5	55.8	22.0	0.8	0	87	19	Natural	No	None
410	do	Sample	14.4	54.7		1.1	2.4	70	28	Musty	Yes	do
564	do	Sample, Tough	14.6	54.4		.9	2.3	61	28	do	Yes	do
894	do	Sample	13.6	55.0		.5	5.0	47	32	do	Yes	do
BIN F-11, FILLED												
0	Average	4, Tough	15.6	53.2	19.5	3.4	(4)	90	18	Natural	No	None
68	do	do	14.9	53.5		3.5	0.2	84	18	do	No	do
200	do	do	15.0	53.7		3.8	.1	77	17	do	No	do
877	do	4	13.2	53.8		2.3	.5	58	29	do	Yes	do
1,222	do	4	13.4	53.4		3.8	1.5	52	36	do	Yes	do

See footnotes at end of table.

in quality throughout bin and temperature data of wheat stored in experimental 1938, and 1939—Continued

SEPT. 2, 1937

Variations shown in other portions of bulk at same storage period								Admixtures	Harvest method or source of wheat	First "maximum" temperature period" in center of bulk [4]				Remarks
Moisture		Normal germination		Fat acidity [3]		Total damaged kernels								
Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum			Initial temperature	"Final" temperature	Average temperature	Length of period	
Pct.	*Pct.*	*Pct.*	*Pct.*	*Units*	*Units*	*Pct.*	*Pct.*			*°F.*	*°F.*	*°F.*	*Dy.*	
----	15.3	----	87	19	------	0.4	----	None	Commercial	84	68	62.0	32	
14.2	12.2	75	----	30	29	1.6	0.3	do	do	84	68	62.0	32	Snow filled inlet pipe. Musty portion is directly under drum.
13.7	12.1	83	36	31	26	----	----	do	do	84	68	62.0	32	
16.8	12.1	72	3	------	------	----	----	do	do	84	68	62.0	32	

SEPT. 2, 1937

15.9	----	87	81	18	16	----	0.0	Lime-sulfur	Commercial	79	80	79.0	-6	
15.6	----	----	77	23	17	0.2	----							

SEPT. 3, 1937

15.8	10.7	----	----	------	------	----	----	Oats	Commercial	76	82	79.0	8	350 bushels of wheat and 189 bushels of oats.
14.8	14.4	83	----	23	21	0.3	----	do	do	76	82	79.0	8	
14.6	14.1	----	83	------	18	----	0.4	do	do	76	82	79.0	8	

SEPT. 2, 1937

----	15.3	90	----	------	17	0.5	----	None	Commercial	76	63	61.5	22	
14.3	14.0	86	82	------	16	.6	0.1			76	63	61.5	22	
16.8	14.6	85	----	17	16	.5	----							

AUG. 16, 1937

14.6	----	90	84	19	------	0.4	----	None	Commercial	77	77	76.5	18	Top of bulk covered by snow during winter.
14.9	13.7	87	48	30	24	----	0	do	do	77	77	76.5	18	
16.0	13.1	87	15	33	22	----	0	do	do	77	77	76.5	18	
16.0	13.6	56	0	43	28	27.6	2.0	do	do	77	77	76.5	18	

EST. 2, 1937

15.7	----	----	87	19	------	0.4	0	None	Commercial	77	70	72.0	12	
15.3	14.7	----	81	19	17	.5	----			77	70	72.0	12	
15.3	----	79	----	18	17	.5	----			77	70	72.0	12	
14.0	12.4	82	42	33	26	----	----			77	70	72.0	12	
14.6	12.7	80	26	------	------	----	----			77	70	72,0	12	

TABLE 35.—*Condition and quality of wheat, harvest method, admixtures, variations bins at Fargo, in 1936, 1937,*

Storage period when sampled (days)[1]	Portion of bulk sampled	Official grade of sample [2]	Moisture content	Test weight per bushel	Weight per 1,000 kernels	Dockage	Total damaged kernels	Normal germination	Fat Acidity [3]	Odor	Fumigated	Weevil and other insect infestation
			Pct.	*Lb.*	*Gm.*	*Pct.*	*Pct.*	*Pct.*	*Units*			
BIN F-12, FILLED												
1	Average	3	14.5	55.8	21.0	0.8	0	89	19	Natural	No	None
217	do	3	14.4	53.5		.9	.1	83	18	do	No	do
217+346	do	3, Tough	14.6	55.0		1.0	.2	73	25	do	Yes	do
217+619	do	3	13.6	55.0		.6	1.3	42	29	do	Yes	do
217+1,020	do	3	13.3	55.2		1.0	1.5	39	36	do	Yes	do
BIN F-28, FILLED												
3	Average	5, Tough	15.4	51.2	19.4	4.8	0.2	86	16	Natural	No	None
199	do	do	15.4	51.0		5.6	.1	86	19	do	No	do
BIN F-29, FILLED												
4	Average	4, Tough	15.6	53.0	19.4	4.0	0.3	85	17	Natural	No	None
199	do	5, Tough	15.6	52.8		4.7	.3	83	17	do	No	do
BIN F-30, FILLED												
0	Average	4, Tough	14.8	53.5	19.1	3.3	0.3	84	17	Natural	No	None
603	do	Sample, Tough	14.6	52.1		3.4	1.4	39	29	Musty	Yes	do
BIN F-31, FILLED												
1	Average	4, Tough	15.2	53.4	19.1	3.5	0.5	84	17	Natural	No	None
732	do	Sample	13.1	53.0		3.7	1.0	40	32	Musty	Yes	do
BIN F-32, FILLED												
0	Average	3	14.5	55.5	21.5	1.1	0	88	19	Natural	No	None
564	do	Sample	16.5	53.5		.9	.8	58	27	Musty	Yes	do
627	do	do	14.2	54.0		.8	3.0	34	31	do	Yes	do
753	do	do	12.2	54.2		1.0	11.5	34	35	do	Yes	do
BIN F-33, FILLED												
0	Average	3	14.5	55.5	21.5	1.1	0	88	18	Natural	No	None
627	do	Sample, Tough	15.2	53.8		.7	2.7	44	28	Musty	Yes	do

See footnotes at end of table.

in quality throughout bin and temperature data of wheat stored in experimental 1938, and 1939—Continued

AUG. 16, 1937

Variations shown in other portions of bulk at same storage period								Admixtures	Harvest method or source of wheat	First "maximum temperature period" in center of bulk [4]				Remarks
Moisture		Normal germination		Fat acidity [3]		Total damaged kernels				Initial temperature	"Final" temperature	Average temperature	Length of period	
Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum							
Pct.	*Pct.*	*Pct.*	*Pct.*	*Units*	*Units*	*Pct.*	*Pct.*			°*F.*	°*F.*	°*F.*	*Dy.*	
----	----	90	84	------	18	0.1	----	None	Commercial	76	77	75.5	23	
15.2	----	----	77	20	------	.2	----	do	do	70	77	75.5	23	200 bushels of wheat removed through bottom and returned to bin after this sampling.
14.8	13.2	89	65	25	21	.6	0	do	do	70	77	7.55	23	
14.2	12.8	78	10	31	23	----	.3	do	do	70	77	76.5	23	
14.5	12.8	75	4	------	------	----	----	do	do	70	77	75.5	23	

SEPT. 4, 1937

----	----	----	----	------	------	----	----	Lime-sulfur	Commercial	68	67	66.0	20	
----	13.9	----	----	------	------	----	----							

SEPT. 4, 1937

----	----	----	----	------	------	----	----	Lime-sulfur	Commercial	69	67	66.0	21	
15.6	14.5	----	----	------	------	----	----							

SEPT. 8, 1937

----	----	----	----	------	------	----	----	None	Commercial	73	67	65.5	16	
15.8	12.9	49	28	35	28	----	----	do	do	73	67	65.5	16	1 inch of snow on top of wheat when sampled, Jan. 7, 1939.

SEPT. 7, 1937

----	----	----	----	------	------	----	----	None	Commercial	72	63	65.0	17	
13.2	12.8	55	36	------	26	----	----	do	do	72	63	65.0	17	Snow on top of wheat when sampled Jan. 7, 1939.

AUG. 17, 1937

----	----	----	----	------	------	----	----	None	Commercial	69	66	70.0	38	
18.8	14.3	64	39	33	28	----	----	do	do	69	66	70.0	38	Snow on top of wheat when sampled Jan. 7, 1939.
----	12.6	----	----	------	------	----	----	do	do	69	66	70.0	38	
12.4	11.7	----	24	------	30	----	----	do	do	69	66	70.0	38	

AUG. 17, 1937

----	----	----	----	------	------	----	----	None	Commercial	70	66	69.5	39	
15.4	14.4	----	34	------	26	----	----	do	do	70	66	69.5	39	Snow on top of wheat when sampled Jan. 7, 1939.

TABLE 35.—*Condition and quality of wheat, harvest method, admixtures, variations bins at Fargo, in 1936, 1937,*

Storage period when sampled (days) [1]	Portion of bulk sampled	Official grade of sample [2]	Moisture content	Test weight per bushel	Weight per 1,000 kernels	Dockage	Total damaged kernels	Normal germination	Fat acidity [3]	Odor [4]	Fumigated	Weevil and other insect infestation
			Pct.	*Lb.*	*Gm.*	*Pct.*	*Pct.*	*Pct.*	*Units*			
BIN F-34, FILLED												
0	Average	3	13.8	56.0	21.5	0.8	(5)	87	19	Natural	No	None
831	do	3	12.5	55.4		.8	0.5	71	29	do	Yes	do
1,225	do	4	13.6	54.6		1.0	.7	68	32	do	Yes	do
BIN F-35, FILLED												
0	Average	3	13.8	56.0	21.5	0.8	(5)	84	21	Natural	No	None
831	do	3	13.3	55.1		1.0	0.6	80	25	do	Yes	do
1,225	do	3	13.9	55.3		.8	2.5	76	34	do	Yes	do
BIN F-36, FILLED												
0	Average	4, Tough	14.8	54.0	19.5	14.8	0.2	90	17	Natural	No	None
195	do	Mixed grain, Tough.	14.6	48.2			.0	82	17	do	No	do
BIN F-37, FILLED												
0	Average	5, Tough	15.0	50.5	19.5	10.4	0.6	90	26	Natural	No	None
195	do	do	14.6	52.0		6.9	.2	82	25	do	No	do
BIN F-38, FILLED												
0	Average	3, Tough	15.3	55.0	21.6	1.1	0.1	84	19	Natural	No	None
222	Inferior	Sample, Tough	15.6					33	35	Sour	No	do
BIN F-39, FILLED												
0	Average	3, Tough	15.2	55.0	21.2	1.1	0.6	84	19	Natural	No	None
209	do	3	14.1	55.0	20.0	.6	.2	40	32	do	No	do
BIN F-3, FILLED												
0	Average	3, Smutty, Tough	14.9	56.0	18.8	0.9	0	81	24	Smutty	No	None
20	Inferior	Sample, Smutty, Tough.	15.8	54.6	19.6	.5	8.5	17	45	Musty	No	do
20+190	Average	Sample, Light smutty, Tough.	14.8	55.6		.7	1.7	48	35	do	Yes	do

See footnotes at end of table.

in quality throughout bin and temperature data of wheat stored in experimental 1938, and 1939—Continued

Variations shown in other portions of bulk at same storage period								Admixtures	Harvest method or source of wheat	First "maximum temperature period" in center of bulk[1]:				Remarks
Moisture		Normal germination		Fat acidity[3]		Total damaged kernels				Initial temperature	"Final" temperature	Average temperature	Length of period	
Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum							
Pct.	*Pct.*	*Pct.*	*Pct.*	*Units*	*Units*	*Pct.*	*Pct.*			°*F.*	°*F.*	°*F.*	*Dy.*	
AUG. 28, 1937														
----	----	----	----	----	----	----	----	None	Commercial	83	67	70.0	27	Wheat dried by elevating and aerating.
14.8	----	81	63	31	27	----	----	do	do	83	67	70.0	27	Snow on top of wheat when sampled Jan. 7, 1939.
13.8	12.8	78	66	34	30	----	----	do	do	83	67	70.0	27	
AUG. 28, 1937														
----	----	----	----	----	----	----	----	None	Commercial	82	64	70.0	28	Wheat dried by elevating and aerating.
13.4	----	86	78	25	24	----	----	do	do	82	64	70.0	28	Snow on top of wheat when sampled Jan. 7, 1939.
14.0	13.2	82	74	32	31	----	----	do	do	82	64	70.0	28	
SEPT. 8, 1937														
15.8	10.7	----	----	----	----	----	----	Oats	Commercial	71	72	63.0	17	
----	----	----	----	----	----	----	----							
SEPT. 8, 1937														
15.8	10.7	----	----	----	----	----	----	Ground oats.	Commercial	69	67	64.0	16	
(7)	13.7	----	----	----	----	----	----							
DEC. 22, 1937														
----	----	----	----	----	----	----	----	None	Commercial	----	----	----	----	Wheat taken from top of bin F-12, after removing top 4 inches of wheat.
----	13.0	64	----	----	31	----	.1	do	do	----	----	----	----	Inferior portion about 1 peck beside flue on floor.
DEC. 30, 1937														
----	----	----	----	----	----	----	----	None	Commercial	----	----	----	----	Wheat taken from top of bin F-12.
15.3	11.7	----	----	----	----	----	----	do	do	----	----	----	----	
AUG. 3, 1938														
15.6	13.8	92	73	26	16	----	----	None	Combine	83	93	88.0	20	
16.0	14.2	88	2	55	19	----	.6	do	do	83	93	88.0	20	Inferior represents ⅓ of upper portion.
16.8	13.6	67	36	38	26	2.4	.7	do	do	83	93	88.0	20	

TABLE 35.—*Condition and quality of wheat, harvest method, admixtures, variations bins at Fargo, in 1936,*

Storage period when sampled (days)[1]	Portion of bulk sampled	Official grade of sample [2]	Moisture content	Test weight per bushel	Weight per 1,000 kernels	Dockage	Total damaged kernels	Normal germination	Fat Acidity [3]	Odor	Fumigated	Weevil and other insect infestation
			Pct.	*Lb.*	*Gm.*	*Pct.*	*Pct.*	*Pct.*	*Units*			
BIN F-4, FILLED												
2	Average	1	13.7	58.8	19.6	0.9	0	86	20	Natural	No	None
38	Middle layer.	Sample, Light smutty, Tough.	14.6	57.2		.8	1.0	24	32	Musty	No	do
38+504	Average	2	13.6	57.7		.8	2.0	39	37	Natural	Yes	do
38+849	do	3	13.5	57.8		1.0	6.3	37	42	do	Yes	do
BIN F-5, FILLED												
0	Average	3, Smutty, Tough	14.9	56.2	19.4	0.9	0.2	71	23	Smutty	No	None
26	do	Sample, Smutty, Tough.	14.6	55.4	18.7	1.1	.6	64	31	Musty	No	Insects
26+514	do	3, Light smutty	13.4	56.0		.9	4.0	53	41	Fumigant	Yes	None
26+861	do	Sample, Light smutty.	12.8	56.2		1.2	8.2	50	44	Musty	Yes	do
BIN F-7, FILLED												
0	Average	3, Light smutty, Tough.	15.4	56.6	19.6	1.1	(5)	78	20	Natural	No	None
28	do	Sample, Light smutty, Tough.	14.8	55.3		.8	11.0	51	37	Musty	Yes	do
28+29	do	do	14.5	56.7		.8	8.7	57	38	do	Yes	do
28+29+151	do	Sample, Tough	14.6	56.7		.7	14.9	49	40	do	Yes	do
BIN F-8, FILLED												
0	Average	3, Light smutty, Tough.	15.1	56.5	19.2	0.8	0	76	20	Smutty	No	None
31	do	3, Light smutty	13.4	56.8		.8	1.2	73	23	do	No	do
542	do	do	12.8	56.6		.7	1.4	64	30	Natural	No	do
887	do	do	12.3	56.7		1.0	.9	76	38	Smutty	No	do
BIN F-9, FILLED												
0	Average	3, Light smutty, Tough.	15.8	56.8	19.5	0.7	0	74	24	Smutty	No	None
58	do	do	14.6	56.0		1.0	4.4	60	35	do	No	do
542	do	2, Light smutty	13.2	56.6		.6	6.0	37	48	Natural	Yes	do
887	do	3, Light smutty	13.0	57.1		.8	7.0	26	57	do	Yes	do

See footnotes at end of table.

in quality throughout bin and temperature data of wheat stored in experimental 1937, 1938, and 1939—Continued

Variations shown in other portions of bulk at same storage period								Admixtures	Harvest method or source of wheat	First "maximum" temperature period" in center of bulk [4]				Remarks
Moisture		Normal germination		Fat acidity [3]		Total damaged kernels								
Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum			Initial temperature	"Final" temperature	Average temperature	Length of period	
Pct.	*Pct.*	*Pct.*	*Pct.*	*Units*	*Units*	*Pct.*	*Pct.*			*°F.*	*°F.*	*°F.*	*Dy.*	
AUG. 3, 1938														
15.8	11.2	----	74	25	16	----	----	None	Combine	84	94	88.0	20	
15.8	12.6	77	12	40	21	----	.0							
14.2	12.5	62	20	43	31	14.9	1.3							
14.7	11.1	65	6	------	------	----	----							
AUG. 3, 1938														
15.4	13.5	88	67	26	19	.3	.0	None	Combine	81	82	80.8	21	
14.9	13.2	88	32	34	18	4.8	.2							
14.4	11.4	82	34	------	25	----	----							
13.8	12.2	78	22	52	34	----	----							
AUG. 3, 1938														
17.1	14.9	90	68	40	17	.6	.0	None	Combine	81	86	84.0	17	
16.0	14.4	87	2	60	17	54.4	.0	do	do	81	86	84.0	17	Inferior portion 100 bushels due to rain entering flue.
19.4	----	58	6	62	36	100.0	8.0	do	do	81	86	84.0	17	Inferior portion 2 bushels due to rain leaking through roof.
16.2	13.2	59	48	43	38	18.5	14.6	do	do	81	86	84.0	17	
AUG. 3, 1938														
17.0	14.8	87	64	------	17	0.8	----	None	Combine	71	82	79.0	24	
15.4	10.8	89	53	48	18	----	----	do	do	71	82	79.0	24	End of forced ventilation period.
13.2	11.2	83	47	61	24	----	----	do	do	71	82	79.0	24	
14.4	11.6	84	49	58	30	----	----	do	do	71	82	79.0	24	
AUG. 3, 1938														
17.8	14.4	86	63	48	17	0.5	----	None	Combine	93	110	100.0	2	
15.3	10.6	88	35	52	17	----	----	do	do	93	110	100.0	2	End of forced ventilation period.
14.8	10.8	94	3	65	18	----	----	do	do	93	110	100.0	2	
14.6	10.7	96	0	------	------	----	----	do	do	93	110	100.0	2	

TABLE 35.—*Condition and quality of wheat, harvest method, admixtures, variations bins at Fargo, in 1936,*

Storage period when sampled (days) [1]	Portion of bulk sampled	Official grade of sample [2]	Moisture content	Test weight per bushel	Weight per 1,000 kernels	Dockage	Total damaged kernels	Normal germination	Fat acidity [3]	Odor	Fumigated	Weevil and other insect infestation
												BIN F-26, FILLED
			Pct.	*Lb.*	*Gm.*	*Pct.*	*Pct.*	*Pct.*	*Units*			
10	Average	3	13.8	55.2	19.4	0.9	0.8	38	35	Natural	No	None
254	do	Sample	15.4	53.8		1.0	2.3	22	36	Musty	No	do
												BIN F-27, FILLED
10	Average	3	12.7	55.8	18.9	0.9	0	78	28	Natural	No	None
472	do	3	12.3	55.3		.7	.5	61	34	do	No	do
472+1	do	3	12.5	55.5		.7	.5	64	32	do	No	do
472+420	do	4	13.7	54.7		1.0	1.0	51	36	do	No	do
												BIN F-28, FILLED
4	Average	1, Light smutty	12.8	59.3	20.3	0.9	0	89	18	Smutty	No	None
366	do	do	12.2	58.9		1.2	.3	74	25	do	No	do
												BIN F-29, FILLED
2	Average	1, Heavy	11.6	60.7	20.4	0.6	0	77	16	Natural	No	None
366	do	do	11.5	60.4		.8	0	82	21	do	No	do
												BIN F-36, FILLED
2	Average	2, Light smutty	14.4	55.5	18.0	1.4	0.5	78	19	Smutty	No	None
368	do	3, Light smutty	13.4	55.0		1.5	2.4	37	33	do	No	do
												BIN F-37, FILLED
2	Average	3, Tough	14.7	56.0	18.9	1.5	0	81	20	Natural	No	None
212	do	4, Light smutty, Tough.	16.0	54.5		1.5	1.0	61	30	Fumigant	Yes	do
306	do	Sample, Light smutty, Tough.	14.6	56.0		1.3	1.0	39	41	Musty	Yes	do

See footnotes at end of table.

in quality throughout bin and temperature data of wheat stored in experimental 1937, 1938, and 1939—Continued

Variations shown in other portions of bulk at same storage period								Admixtures	Harvest method or source of wheat	First "maximum temperature period" in center of bulk [4]				Remarks
Moisture		Normal germination		Fat acidity [3]		Total damaged kernels				Initial temperature	"Final" temperature	Average temperature	Length of period	
Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum							
JULY 27, 1938														
Pct.	*Pct.*	*Pct.*	*Pct.*	*Units*	*Units*	*Pct.*	*Pct.*			°*F.*	°*F.*	°*F.*	*Dy.*	
----	13.6	39	25	37	----	----	----	None	Commercial	89	71	75.5	35	Wheat from 1937 crop stored in F-12 and F-39.
16.8	----	28	----	37	35	----	----	do	do	89	71	75.5	35	Snow accumulated in top of bin during winter.
JULY 27, 1938														
12.9	12.5	----	60	29	26	----	----	None	Commercial	86	73	76.0	40	Wheat from 1937 crop stored in F-12 and F-38.
12.8	11.6	----	55	34	32	----	----	do	do	86	73	76.0	40	
12.2	11.5	66	61	32	31	----	----	do	do	86	73	76.0	40	
14.0	12.7	49	42	38	36	----	----	do	do	86	73	76.0	40	
AUG. 4, 1938														
13.0	12.6	----	72	20	----	----	----	None	Combine	85	73	78.0	34	
12.3	11.4	----	67	----	19	----	----							
AUG. 4, 1938														
----	11.4	80	74	----	15	----	----	None	Combine	84	74	78.0	27	
11.7	11.3	85	74	----	17	----	----							
AUG. 4, 1938														
14.6	14.0	93	76	21	----	----	----	None	Combine	79	84	82.2	7	
----	12.6	59	----	----	26	----	----							
AUG. 4, 1938														
----	14.4	82	----	----	20	----	----	None	Combine	85	88	87.0	15	
16.2	15.5	66	57	----	24	----	----	do	do	85	88	87.0	15	Snow accumulated in top of bin during winter.
14.8	14.0	41	34	----	33	----	----	do	do	85	88	87.0	15	

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TABLE 35.—*Condition and quality of wheat, harvest method, admixtures, variations bins at Fargo, in 1936,*

Storage period when sampled (days)[1]	Portion of bulk sampled	Official grade of sample [2]	Moisture content	Test weight per bushel	Weight per 1,000 kernels	Dockage	Total damaged kernels	Normal germination	Fat Acidity [3]	Odor	Fumigated	Weevil and other insect infestation
			Pct.	*Lb.*	*Gm.*	*Pct.*	*Pct.*	*Pct.*	*Units*			
BIN F-38, FILLED												
2	Average	3, Light smutty, Tough.	15.0	56.2	18.5	1.4	0	77	20	Smutty	No	None
212	do	Sample, Light smutty.	18.3	53.0		1.1	1.0	71	23	Natural	No	do
490	do	3, Light smutty	12.4	56.3		1.2	5.8	62	34	do	No	do
576	do	Sample, Light smutty.	13.0	56.0		1.0	5.7	13	56	Musty	No	do
BIN F-39, FILLED												
2	Average	3, Light smutty, Tough.	15.1	56.0	18.0	1.1	0	77	20	Smutty	No	None
211	do	Sample, Light smutty.	16.3	54.6		1.0	.4	51	35	Natural	No	do
490	do	do	13.8	55.6		1.0	7.0	13	52	Musty	No	do
BIN F-3, FILLED												
4	Average	1	10.6	58.7	25.8	1.1	0.4	90	15	Natural	No	None
176	do	1	10.7	58.5	25.6	.5	.4	90	11	do	No	do
BIN F-28, FILLED												
11	Average	2	12.1	59.0		0.8	3.1	70	26	Natural	No	None
289	do	2	12.4	59.0		.8	2.5	59	29	do	No	do
499	do	2	12.3	59.2		.8	2.2	67	35	do	No	do
BIN F-36, FILLED												
11	Average	2	12.0	59.0		0.8	3.4	68	28	Natural	No	None
289	do	2	12.4	58.8		.7	2.8	63	30	do	No	do
499	do	2	13.2	58.7		1.0	2.5	68	36	do	No	do

[1] Plus sign (+) indicates that grain was moved after previous sampling. Total storage period for any sample is sum of figures, added horizontally.
[2] All wheat of class Hard Red Spring and subclass Dark Northern Spring except where noted.
[3] Fat acidity for all samples drawn in 1936, was calculated from acid value determination and average oil content of hard red spring wheat

in quality throughout bin and temperature data of wheat stored in experimental 1937, 1938, and 1939—Continued

Variations shown in other portions of bulk at same storage period								Admixtures	Harvest method or source of wheat	First "maximum" temperature period" in center of bulk [4]				Remarks
Moisture		Normal germination		Fat acidity [3]		Total damaged kernels								
Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum			Initial temperature	"Final" temperature	Average temperature	Length of period	
Pct.	*Pct.*	*Pct.*	*Pct.*	*Units*	*Units*	*Pct.*	*Pct.*			°*F.*	°*F.*	°*F.*	*Dy.*	
AUG. 4, 1938														
----	14.4	84	----	20	20	---	----	None	Combine	79	72	73.3	27	
22.0	16.8	74	56	------	20	----	----	do	do	79	72	73.3	27	Excessive amount of snow accumulated in top of bin. Removed before this sampling.
12.6	12.0	64	44	41	32	----	----	do	do	79	72	73.3	27	
13.2	13.0	72	43	43	28	----	----	do	do	79	72	73.3	27	
AUG. 4, 1938														
----	14.4	84	73	20	------	----	----	None	Combine	86	82	84.5	26	Snow accumulated in top of bin during winter.
17.3	----	67	41	42	25	----	----							
14.0	13.4	26	12	57	44	----	----							
AUG. 18, 1939														
10.7	10.2	93	84	------	10	0.6	----	None	Threshed	86	62	75.2	68	
12.4	10.0	92	88	13	9	.5	----							
AUG. 25, 1939														
----	11.7	72	64	28	------	----	----	None	Combine	----	----	----	----	
13.0	11.5	69	----	32	28	----	----							
12.6	11.8	68	68	36	34	----	----							
AUG. 25, 1939														
----	11.7	76	----	------	23	----	----	None	Combine	----	----	----	----	
13.7	12.2	70	60	30	27	----	----							
13.1	12.8	74	70	34	31	----	----							

[4] Ordinarily if newly harvested wheat heats in the bin it is during the initial storage period. The temperature data given is for only the period stated in the length of period column.

[5] Trace.

[6] Fat acidity of samples taken Feb. 18, 1958.

[7] Rotten watery wheat in layer 1½ inches thick on floor for 1 foot from north and west walls.

TABLE 36.—*Description of experimental bins filled at Hays, in 1936, 1937, 1938, and 1939*

Bin No.	Location of bin	Roof type	Bin surfaces contacting wheat: Floor—material	Bin surfaces contacting wheat: Walls: Material	Bin surfaces contacting wheat: Walls: Number exposed to sun	Bin surfaces contacting wheat: Walls: Resistance to heat transfer [1]	Bulk aeration: Type	Bulk aeration: Air paths through bulk: Average	Bulk aeration: Air paths through bulk: Range	Bulk measurements: Quantity	Bulk measurements: Average depth	Bulk measurements: Half minimum width
								Feet	*Feet*	*Bushels*	*Feet*	*Feet*
BINS FILLED IN 1936												
H-1	Outdoors	Metal	Metal	Metal	(2)	0.7	None	0	0	502	7.9	5.0
H-2		Insulated metal	do	Wallboard lining	0	3.12	do	0	0	440	7.0	4.8
H-3		Roll	Wood	Wood	(2)	1.68	do	0	0	560	7.0	5.0
H-4		do	Concrete	Concrete staves	(2)	1.02	do	0	0	424	7.5	5.0
H-5		Metal	Screen	Metal	(2)	.7	Bottom surface	6.0	0	782	6.0	7.0
H-6		do	Metal	Perforated metal	(2)	.7	Forced (wind)	6.7	8.5	739	5.7	3.1
H-7		do	do	Metal	(2)	.7	None	0	0	780	6.3	7.0
H-8		do	do	do	(2)	.7	Power	6.5	1.7	780	6.3	7.0
H-9		do	do	do	(2)	.7	None	0	0	20	3.0	1.6
H-10		Wallboard	Insulated metal	Insulated metal	(2)	10.69	do	0	0	20	3.0	1.6
H-11		Metal	Metal	Metal	(2)	.7	do	0	0	20	3.0	1.6
H-12		Wallboard	Insulated metal	Insulated metal	(2)	10.69	do	0	0	20	3.0	1.6
H-13		Metal	Metal	Metal	(2)	.7	do	0	0	20	3.0	1.6
H-14		Wallboard	Insulated metal	Insulated metal	(2)	10.69	do	0	0	20	3.0	1.6
H-15		Metal	Metal	Metal	(2)	.7	do	0	0	20	3.0	1.6
H-16		Wallboard	Insulated metal	Insulated metal	(2)	10.69	do	0	0	20	3.0	1.6
H-17		Metal	Metal	Metal	(2)	.7	do	0	0	20	3.0	1.6
H-18		Wallboard	Insulated metal	Insulated metal	(2)	10.69	do	0	0	18	3.0	1.6
BINS FILLED IN 1937												
H-1E	Outdoors	Metal	Metal	Metal	3	0.7	None	0	0	230	6.6	5.0
H-1W		do	do	do	3	.7	do	0	0	236	6.4	5.0
H-2E		do	do	do	3	.7	do	0	0	210	7.9	5.0
H-2W		do	do	do	3	.7	do	0	0	250	8.0	5.0
H-3W		Roll	Wood	Wood	3	1.68	do	0	0	250	6.5	2.5
H-4E		do	Concrete	Concrete	3	.95	do	0	0	240	7.6	5.0
H-4W		do	do	do	3	.95	do	0	0	260	6.3	5.0
H-6W		Metal	Metal	Perforated metal	3	.7	Power	6.0	11.0	500	7.9	3.1
H-7E		do	Perforated metal	do	3	.7	do	3.8	1.5	500	8.0	7.0
H-7W		do	Metal	Paper-lined metal	3	+.7	do	3.2	1.5	500	8.0	7.0
H-8W		do	do	Metal	3	.7	Forced (wind)	3.5	5.4	500	7.8	3.5

H-9	Underground	Concrete	Concrete	Concrete	0	.53	Restricted			92	4.5	2.8
H-10	Outdoors	Roll	Perforated metal	Metal foil	2	4.37	Bottom surface	4.0	0	64	4.0	2.0
H-11		do	do	do	2	4.37	do	4.0	0	96	6.0	2.0
H-12		do	do	do	2	4.37	do	4.0	0	128	8.0	2.0
H-20	Underground	Metal	Metal	Metal	0	.45	Restricted			20	3.1	1.6
H-21		do	do	do	0	.45	do			20	3.1	1.6
H-22		do	do	do	0	.45	do			20	3.1	1.6
H-23		do	do	do	0	.45	Restricted—sealed			20	3.1	1.6
H-24		do	do	do	0	.45	do			20	3.1	1.6
H-25	Outdoors	do	do	do	(2)	.7	None	0	0	20	3.1	1.6
H-26		do	do	do	(2)	.7	do	0	0	20	2.9	1.6
H-27		do	do	do	(2)	.7	do	0	0	20	2.9	1.6
H-28		do	do	do	(2)	.7	do	0	0	25	2.7	1.9
H-29		do	do	do	(2)	.7	do	0	0	25	2.7	1.9
H-30		do	do	do	(2)	.7	do	0	0	25	3.2	1.9
H-31		Wallboard	Insulated metal	Insulated metal	(2)	10.69	do	0	0	20	2.9	1.6
H-32		Open shed	Metal	Metal	(3)	.7	do	0	0	20	3.0	1.6
H-33		Wallboard	do	do	(2)	.7	Ducts	1.5	1.5	30	3.0	1.9
BINS FILLED IN 1938												
H-2	Outdoors	Metal	Metal	Metal	(2)	0.7	None	0	0	486	7.7	5.0
H-5		do	Screen	do	(2)	.7	Bottom surface	8.0	0	992	8.0	7.0
H-6		do	Metal	Perforated metal	(2)	.7	Power	6.2	9.1	825	6.8	3.1
H-7		do	do	do	(2)	.7	do	6.0	8.9	934	7.4	7.0
H-8		do	do	Metal	(2)	.7	None	0	0	772	6.3	7.0
H-10		Roll	Perforated metal	Metal foil	(2)	4.37	Forced (wind)	3.9	0	62	3.9	2.0
H-11		do	do	do	2	4.37	do	5.9	0	94	5.9	2.0
H-12		do	do	do	2	4.37	do	7.8	0	125	7.8	2.0
H-26		Metal	Metal	Metal	(2)	.7	None	0	0	17	2.5	1.6
H-29		do	do	do	(2)	.7	do	0	0	21	2.3	1.9
H-41	Underground	Concrete	Concrete	Concrete [4]	0	.53	do	0	0	1,004	9.3	6.5
H-42		do	do	do [4]	0	.53	do	0	0	1,022	9.5	6.5
BINS FILLED IN 1939												
H-41	Underground	Concrete	Concrete	Screen-lined concrete	0		Forced (wind)	6.5	6.0	1,000	10.2	3.1
H-44	Outdoors	Metal	Perforated metal	Metal	(2)	0.7	Power	8.1	0	1,000	8.1	7.0

[1] Resistance or degrees Fahrenheit difference in temperature on opposite surfaces of wall which will cause 1 B. t. u. of heat to pass through an area of 1 square foot in 1 hour.
[2] All walls supporting wheat exposed to sun.
[3] Parts of three walls exposed to sun.
[4] See text ,page 99.

TABLE 37.—*Condition and quality of wheat, harvest method, admixtures, variations Hays, in 1936, 1937,*

Storage period when sampled (days) [1]	Portion of bulk sampled	Official grade of sample [2]	Moisture content	Test weight per bushel	Weight per 1,000 kernels	Dockage	Total damaged kernels	Normal germination	Fat acidity [3]	Odor	Fumigated	Weevil and other insect infestation
			Pct.	*Lb.*	*Gm.*	*Pct.*	*Pct.*	*Pct.*	*Units*			
BIN H-1, FILLED												
0	Average	4	12.5	54.8	21.5	0.9	1.0	83	12	Natural	No	None
9	Bottom layer.	Sample, Tough	14.4	52.0		1.0	1.7	68		Sour	No	do
12+12+24	Average	Sample	12.3	55.3		.6	2.0	75		do	No	do
BIN H-2, FILLED												
0	Average	4	12.8	54.7	21.0	1.0	1.6	81	12	Natural	No	None
9	Bottom half.	Sample, Tough	14.6	51.0		.8	2.5	20		Sour	No	do
12+12+24	Average	Sample	12.1	55.5		.7	2.2	80		do	No	do
BIN H-3, FILLED												
0	Average	4	12.7	55.5	21.0	0.8	0.6	89	12	Natural	No	None
9	Bottom layer.	Sample, Tough	15.2	50.4		.7	2.4	28		Sour	No	do
12+13+20	Average	Sample	11.8	55.7		.7	.9	78		do	No	do
BIN H-4, FILLED												
0	Average	3	12.0	56.0	22.5	0.9	0.8	88	12	Natural	No	None
9	Bottom layer.	Sample, Tough	14.3	50.5		.7	2.4	33		Sour	No	do
13+12+2	Average	Sample	12.4	55.0		.7	2.7	63		do	No	do
BIN H-5, FILLED												
1	Average	3	12.9	56.0	21.0	1.1	1.8	85	9	Natural	No	None
154+468	do	4	11.3	55.5	23.3	.6	.9	74	17	do	Yes	do
154+577+9	do	3	11.7	56.1	22.0	.5	1.1	63	20	do	Yes	do
BIN H-6, FILLED												
1	Average	4	13.0	55.3	21.0	1.3	1.6	80	9	Natural	No	None
10	Inferior	Sample	13.3	51.0		1.8	7.0			Sour	No	do
17	do	do	15.4	48.5		4.0	10.0	11		Musty	No	do
17+31	Average	do	11.6	56.0		.7	2.7	87	9	Sour	No	do

See footnotes at end of table.

in quality throughout bin and temperature data of wheat stored in experimental bins at 1938, and 1939

Variations shown in other portions of bulk at same storage period								Admixtures	Harvest method or source of wheat	First "maximum temperature period" in center of bulk [4]				Remarks
Moisture		Normal germination		Fat acidity [3]		Total damaged kernels				Initial temperature	"Final" temperature	Average temperature	Length of period	
Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum							
Pct.	*Pct.*	*Pct.*	*Pct.*	*Units*	*Units*	*Pct.*	*Pct.*			*°F.*	*°F.*	*°F.*	*Dy.*	
JUNE 29, 1936														
13.2	12.0	----	----	----	----	----	----	None	Combine	105	118	111.1	7	
----	12.2	81	----	----	----	----	----	do	do	105	118	111.1	7	Bottom portion of bulk heating.
----	----	----	----	----	----	----	----	do	do	105	118	111.1	7	Moved and mixed July 11 and 24. Subsequent movements did not remove sour odor noted on this date.
JUNE 29, 1936														
13.2	12.0	----	----	----	----	----	----	None	Combine	102	115	108.2	9	
----	12.2	----	----	----	----	----	----	do	do	102	115	108.2	9	Bottom portion of bulk heating.
----	----	----	----	----	----	----	----	do	do	102	115	108.2	9	Moved and mixed July 11 and 24.
JUNE 29, 1936														
13.2	12.0	----	----	----	----	----	----	None	Combine	104	112	108.2	6	
----	12.0	84	----	----	----	----	----	do	do	104	112	108.2	6	Bottom portion of bulk heating.
----	----	----	----	----	----	----	----	do	do	104	112	108.2	6	Moved and mixed July 11 and 25.
JUNE 29, 1936														
13.2	----	----	----	----	----	----	----	None	Combine	100	114	109.4	6	
----	11.8	75	----	----	----	----	----	do	do	100	114	109.4	6	Bottom portion of bulk heating—20 bushels.
----	----	----	----	----	----	----	----	do	do	100	114	109.4	6	Moved and mixed July 12 and 25.
JUNE 26, 1936														
----	----	----	----	----	----	----	----	None	Combine	103	81	82.6	34	
11.7	10.9	79	69	19	15	----	----	do	do	103	81	82.6	34	Moved and weighed Nov. 28, 1936.
12.6	10.8	66	58	21	19	----	----	do	do	103	81	82.6	34	Data from first sample of H-8 filled June 28, 1938.
JUNE 26, 1936														
----	----	----	----	----	----	----	----	None	Combine	108	109	103.0	9	
----	12.0	----	----	----	----	----	----	do	do	108	109	103.0	9	Center portion of bulk heating—10 bushels.
----	11.8	82	----	----	----	----	----	do	do	108	109	103.0	9	Center portion of bulk heating—75 bushels.
----	----	----	----	----	----	----	----	do	do	108	109	103.0	9	Moved and mixed July 13, 1936.

TABLE 37.—*Condition and quality of wheat, harvest method, admixtures, variations Hays, in 1936, 1937, 1938,*

Storage period when sampled (days)[1]	Portion of bulk sampled	Official grade of sample [2]	Moisture content	Test weight per bushel	Weight per 1,000 kernels	Dockage	Total damaged kernels	Normal germination	Fat acidity [3]	Odor	Fumigated	Weevil and other insect infestation
			Pct.	*Lb.*	*Gm.*	*Pct.*	*Pct.*	*Pct.*	*Units*			
BIN H-7, FILLED												
1	Average	4	12.8	55.5	21.5	1.1	2.0	86	9	Natural	No	None
12	Inferior	Sample	14.4	52.4		1.2				Sour	No	do
17+24	do		12.4	55.7		.9	3.9	71		do	No	do
BIN H-8, FILLED												
1	Average	4	13.1	55.7	23.5	1.0	1.8	90	8	Natural	No	None
95	do	Sample	11.6	55.7	22.0	.6	2.0	88		Sour	No	Insects
BIN H-9, FILLED												
0	Average	3	12.0	56.4	23.0	0.8	1.6	82		Natural	No	None
96	do	Sample	12.6	56.0	21.7	.6	1.7	82		Sour	No	Insects
BIN H-10, FILLED												
0	Average	4	11.8	55.4	22.4	0.8	3.0	87		Natural	No	None
96	do	Sample	12.4	56.5	21.5	.6	1.3	85		Sour	No	Weevils
BIN H-11, FILLED												
0	Average	5	13.5	51.5	22.0	2.0	2.2	88		Natural	No	None
96	do	Sample	13.6	51.3	23.2	1.3	4.0	38		Sour	No	Weevils
BIN H-12, FILLED												
0	Average	4	11.8	54.7	20.0	0.9	1.8	92		Natural	No	None
96	do	Sample	12.6	53.0	19.7	.6	1.7	62		Sour	No	Weevils
BIN H-13, FILLED												
0	Average	5, Tough	14.6	51.0	20.6	1.8	2.3	90		Natural	No	None
96	do	Sample, Tough	[5]1.5	51.7	21.3	1.2	26.0	24		Sour	No	Weevils
355	do	do	14.8	48.7		1.5	75.0		44	Musty		
BIN H-14, FILLED												
0	Average	Sample, Tough	14.5	50.5	20.3	2.0	2.4	82		Natural	No	None
96	do	do	[5]15.0	50.5	19.8	1.3	72.0	34		Sour	No	Weevils
355	do	do	15.2	50.1		1.5	36.0	35	36	Musty		

See footnotes at end of table.

in quality throughout bin and temperature data of wheat stored in experimental bins at and 1939—Continued

Variations shown in other portions of bulk at same storage period								Admixtures	Harvest method or source of wheat	First "maximum temperature period" in center of bulk [4]				Remarks
Moisture		Normal germination		Fat acidity [3]		Total damaged kernels				Initial temperature	"Final" temperature	Average temperature	Length of period	
Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum							
Pct.	*Pct.*	*Pct.*	*Pct.*	*Units*	*Units*	*Pct.*	*Pct.*			*°F.*	*°F.*	*°F.*	*Dy.*	
JUNE 26, 1936														
---	---	---	---	---	---	---	---	None	Combine	108	127	119.3	10	
---	12.8	---	---	---	---	---	---	do	do	108	127	119.3	10	Center portion of bulk heating—25 bushels.
---	---	---	---	---	---	---	---	do	do	108	127	119.3	10	Moved and mixed July 13, 1936.
JUNE 26, 1936														
---	---	---	---	---	---	---	---	None	Combine	103	84	79.2	58	
---	---	---	---	---	---	---	---	do	do	103	84	79.2	58	
JUNE 25, 1936														
---	---	---	---	---	---	---	---	None	Combine	116	96	95.5	26	
---	---	---	---	---	---	---	---	do	do	116	96	95.5	26	Green and immature.
JUNE 25, 1936														
---	---	---	---	---	---	---	---	None	Combine	115	93	91.0	58	
---	---	---	---	---	---	---	---	do	do	115	93	91.0	58	Green and immature.
JUNE 25, 1936														
---	---	---	---	---	---	---	---	None	Combine	117	103	95.0	58	
---	---	---	---	---	---	---	---	do	do	117	103	95.0	58	Bottom portion of bulk very bad, sour and musty.
JUNE 25, 1936														
---	---	---	---	---	---	---	---	None	Combine	117	97	93.5	59	
---	---	---	---	---	---	---	---	do	do	117	97	93.5	59	Green and discolored.
JUNE 25, 1936														
---	---	---	---	---	---	---	---	None	Combine	110	114	109.8	24	
---	---	---	---	---	---	---	---	do	do	110	114	109.8	24	Sick and discolored.
---	---	---	---	---	---	---	---	do	do	110	114	109.8	24	Very sour, musty, and moldy.
JUNE 25, 1936														
---	---	---	---	---	---	---	---	None	Combine	108	112	109.5	22	
---	---	---	---	---	---	---	---	do	do	108	112	109.5	22	Sour, musty, and moldy—very bad on bottom.
---	---	---	---	---	---	---	---	do	do	108	112	109.5	22	

TABLE 37.—*Condition and quality of wheat, harvest method, admixtures, variations Hays, in 1936, 1937, 1938,*

Storage period when sampled (days) [1]	Portion of bulk sampled	Official grade of sample [2]	Moisture content	Test weight per bushel	Weight per 1,000 kernels	Dockage	Total damaged kernels	Normal germination	Fat acidity [3]	Odor	Fumigated	Weevil and other insect infestation
			Pct.	*Lb.*	*Gm.*	*Pct.*	*Pct.*	*Pct.*	*Units*			
BIN H-15, FILLED												
0	Average	Sample	17.8	48.5	23.0	2.8	2.8	71		Natural	No	None
8	do	do	15.8	52.3		2.3	9.0			Sour	No	do
96	do	do	15.9	49.7	20.0	2.3	86.0	16		do	No	Weevils
BIN H-16, FILLED												
0	Average	Sample	18.1	48.0	23.0	3.3	3.0	84		Natural	No	None
8	do	do	17.2	51.5		2.4	32.0			Sour	No	do
96	do	Sample, Tough	14.6	50.0	22.5	2.2	87.0	23		do	No	Weevils
BIN H-17, FILLED												
0	Average	Sample	17.6	50.0	25.0	2.8	2.0	86		Natural	No	None
8	do	do	16.2	53.6		2.1	8.0			Sour	No	do
96	do H	Sample, Tough	15.3	50.7	22.5	1.9	78.0	26		do	No	Weevils
BIN H-18, FILLED												
0	Average	Sample	17.8	50.0	24.0	3.2	2.3	78		Natural	No	None
8	do	do	15.8	53.5		1.9	37.0			Sour	No	do
96	do	do	14.0	51.2	21.7	1.7	86.0	23		do	No	do
BIN H-1-E, FILLED												
1	Average	1, Tough	15.4	61.1	25.3	0.3	0	71	20	Natural	No	None
16	do	Sample, Tough	14.6	59.3	25.7		3.8	45	28	Musty	No	do
BIN H-1-W, FILLED												
6	Average	1	13.4	60.2			0.4	72	19	Natural	No	None
68	do	1	13.3	60.1	23.7		1.8	56	24	do	No	do
BIN H-2-E, FILLED												
1	Average	1, Tough	15.4	61.1	25.3	0.3	0	71	20	Natural	No	None
15	do	Sample, Tough	14.9	59.3	25.5	.4	4.0	24	29	Musty	No	do

See footnotes at end of table.

in quality throughout bin and temperature data of wheat stored in experimental bins at and 1939—Continued

Variations shown in other portions of bulk at same storage period								Admixtures	Harvest method or source of wheat	First "maximum" temperature period" in center of bulk [4]				Remarks
Moisture		Normal germination		Fat acidity [3]		Total damaged kernels				Initial temperature	"Final" temperature	Average temperature	Length of period	
Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum							
Pct.	*Pct.*	*Pct.*	*Pct.*	*Units*	*Units*	*Pct.*	*Pct.*			*°F.*	*°F.*	*°F.*	*Dy.*	
JUNE 25, 1936														
----	----	----	----	----	----	----	----	None	Combine	115	123	115.5	24	
----	----	----	----	----	----	----	----	do	do	115	123	115.5	24	Sick, green, and moldy.
----	----	----	----	----	----	----	----	do	do	115	123	115.5	24	Very sour, musty, and moldy. 20 percent heat damaged.
JUNE 25, 1936														
----	----	----	----	----	----	----	----	None	Combine	115	131	123.0	31	
----	----	----	----	----	----	----	----	do	do	115	131	123.0	31	
----	----	----	----	----	----	----	----	do	do	115	131	123.0	31	Sour, musty, moldy, very bad on bottom. 50 percent heat damaged.
JUNE 25, 1936														
----	----	----	----	----	----	----	----	Straw	Combine	113	126	114.8	24	
----	----	----	----	----	----	----	----	do	do	113	126	114.8	24	Heating. Green and sick wheat.
----	----	----	----	----	----	----	----	do	do	113	126	114.8	24	25 per-cent heat-damaged. Very sour and moldy.
JUNE 25, 1936														
----	----	----	----	----	----	----	----	Straw	Combine	114	129	117.0	23	
----	----	----	----	----	----	----	----	do	do	114	129	117.0	23	Heating. Green and sick wheat.
----	----	----	----	----	----	----	----	do	do	114	129	117.0	23	44 per-cent heat-damaged. Very sour and moldy.
JUNE 30, 1937														
15.4	13.9	69	40	30	20	4.5	0	None	Commercial	84	117	95.0	15	
JULY 7, 1937														
----	----	----	----	----	----	----	----	None	Commercial	93	100	94.0	26	Wheat dried by elevating over 15 times.
----	----	----	----	----	----	----	----	do	do	93	100	94.0	26	
JUNE 30, 1937														
----	----	----	----	----	----	----	----	Straw	Commercial	80	107	89.0	14	Same as wheat in H-1-E, but straw added.
----	----	----	----	----	----	----	----	do	do	80	107	89.0	14	Straw removed, wheat heating.

TABLE 37.—*Condition and quality of wheat, harvest method, admixtures, variations Hays, in 1936, 1937, 1938,*

Storage period when sampled (days) [1]	Portion of bulk sampled	Official grade of sample [2]	Moisture content	Test weight per bushel	Weight per 1,000 kernels	Dockage	Total damaged kernels	Normal germination	Fat acidity [3]	Odor	Fumigated	Weevil and other insect infestation
			Pct.	*Lb.*	*Gm.*	*Pct.*	*Pct.*	*Pct.*	*Units*			
BIN H-2-W, FILLED												
1	Average	1, Tough	14.4	60.6	24.3	0.2	0	80	17	Natural	No	None
48	do	Sample, Tough	14.6	57.7			5.0	12	33	Musty	No	do
59	Inferior	do	14.5	56.6			22.0	0	45	do	No	do
BIN H-3-W, FILLED												
1	Average	1, Tough	14.4	61.0	25.0	0.2	0	80	18	Natural	No	None
34	Middle layer.	Sample, Tough	14.8	58.1			2.7	6	32	Musty	No	do
48	Average	do	14.2	58.7	23.0		2.5	37	29	do	No	do
BIN H-4-E, FILLED												
2	Average	1, Tough	15.3	61.0	25.3	0.2	0	68	20	Natural	No	None
17	do	Sample, Tough	15.1	58.0			10.0	23	20	Musty	No	do
BIN H-4-W, FILLED												
1	Average	1, Tough	14.8	60.3	23.3	0.2		80	19	Natural	No	None
41	do	Sample, Tough	14.5	58.2				23	28	Musty	No	do
48	do	do	14.6	57.9			7.0	19	31	do	No	do
BIN H-6-W, FILLED												
1	Average	1, Tough	15.3	61.0	26.2	0.1	(6)	67	20	Natural	No	None
63	do	3, Tough	14.1	59.8			5.6	26	30	do	No	Weevils
74	Inferior	Sample, Tough	14.7	59.2	27.0		5.4	2	49	Musty	No	None
BIN H-7-E, FILLED												
0	Average	1, Tough	15.4	61.4	26.1	0.1	(6)	71	20	Natural	No	None
48	do	1	10.2	61.2			2.0	72	22	do	No	do
58	do	1	10.5	61.4	26.0	.2	1.5	72	20	do	No	do
BIN H-7-W, FILLED												
1	Average	1, Tough	15.2	61.4	26.6	0.1	(6)	72	18	Natural	No	None
49	do	1	10.0	61.4			1.5	65	24	do	No	do
59	do	1	9.7	61.8	26.3	.2	1.0	72	21	do	No	do

See footnotes at end of table.

in quality throughout bin and temperature data of wheat stored in experimental bins at and 1939—Continued

JUNE 30, 1937

Variations shown in other portions of bulk at same storage period								Admixtures	Harvest method or source of wheat	First "maximum temperature period" in center of bulk [4]				Remarks
Moisture		Normal germination		Fat acidity [3]		Total damaged kernels				Initial temperature	"Final" temperature	Average temperature	Length of period	
Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum							
Pct.	*Pct.*	*Pct.*	*Pct.*	*Units*	*Units*	*Pct.*	*Pct.*			°*F.*	°*F.*	°*F.*	*Dy.*	
----	----	----	----	----	----	----	----	None	Commercial	84	98	89.0	85	
15.2	14.3	32	10	38	28	5.5	2.0	do	do	84	98	89.0	85	
----	13.9	30	----	----	26	----	5.0	do	do	84	98	39.0	85	No average sample secured.

JUNE 30, 1937

----	----	----	----	----	----	----	----	None	Commercial	85	107	92.0	50	
----	13.4	61	----	----	24	3.5	1.5	do	do					Musty odor reported by sampler but not by grader.
14.5	13.6	71	15	32	24	----	1.5	do	do	85	107	92.0	50	

JUNE 30, 1937

----	----	----	----	----	----	----	----	Straw in sacks	Commercial	83	115	93.0	17	
----	----	----	----	----	----	----	----							

JUNE 30, 1937

----	----	----	----	----	----	----	----	None	Commercial	83	112	94.0	37	
15.1	13.5	36	1	46	28	15.0	3.5							

JUNE 29, 1937

----	----	----	----	----	----	----	----	None	Commercial	77	100	82.0	49	
14.2	13.0	42	----	31	26	5.8	2.7	do	do	77	100	82.0	49	
----	12.8	48	----	----	27	----	4.2	do	do	77	100	82.0	49	Slightly caked in center of bin, 1 inch of rotten wheat on floor of bin.

JUNE 30, 1937

10.9	9.6	----	65	23	22	2.3	1.5	None	Commercial	83	90	85.0	19	
----	----	----	----	----	----	----	----							

JUNE 29, 1937

----	----	----	----	----	----	----	----	None	Commercial	63	87	75.0	16	
----	9.5	75	----	----	21	----	1.0							
----	----	----	----	----	----	----	----							

TABLE 37.—*Condition and quality of wheat, harvest method, admixtures, variations Hays, in 1936, 1937, 1938,*

Storage period when sampled (days)[1]	Portion of bulk sampled	Official grade of sample [2]	Moisture content	Test weight per bushel	Weight per 1,000 kernels	Dockage	Total damaged kernels	Normal germination	Fat acidity [3]	Odor	Fumigated	Weevil and other insect infestation
			Pct.	*Lb.*	*Gm.*	*Pct.*	*Pct.*	*Pct.*	*Units*			
BIN H-8-W, FILLED												
1	Average	1, Tough	15.5	61.3	25.5	0.2	(6)	69	20	Natural	No	None
35	Middle layer.	Sample, Tough	15.4	57.6			2.3	17	35	Musty	No	do
63	Average	do	14.2	60.0			6.7	31	31	do	No	Insects
74	do	do	14.2	58.5	25.5		6.5	23	43	do	No	Weevils
BIN H-9, FILLED												
1	Average	1	13.0	62.1	30.0	0.5	0.5	90	10	Natural	No	None
254	Top layer	Sample	16.0	58.0	32.0		6.0	37	30	do	Yes	do
428	Average	do	13.9	60.4	32.4	.4	9.7	31	24	Sour	Yes	do
584	do	do	13.9	60.6		.2	11.0	43	23	do	Yes	do
BIN H-10, FILLED												
2	Average	1, Tough	15.2	61.1	24.3	0.2	0.2	70	20	Natural	No	None
16	do	Sample, Tough	15.5	58.2			5.0	17	33	Musty	No	do
16+32	do	do	14.1	57.5			9.0	8	52	do	No	do
BIN H-11, FILLED												
2	Average	Sample	15.8	61.2	25.4	0.2	0	71	21	Natural	No	None
20	do	Sample, Tough	14.9	59.0			.1	25	32	Musty	No	do
20+27	do	do	14.3	57.6			8.5	3	51	do	No	do
BIN H-12, FILLED												
2	Average	1, Tough	15.2	61.6	24.5	0.1	0	67	20	Natural	No	None
19	do	Sample, Tough	14.8	59.4			4.2	26	26	Musty	No	do
19+29	do	do	14.3	59.2			7.0	2	52	do	No	do
BIN H-20, FILLED												
1	Average	1	13.1	60.0	24.0	0.2	(6)	80	21	Natural	No	None
404	do	Sample	14.0	59.4	25.3	.1	(6)	31	28	Musty	Yes	do
BIN H-21, FILLED												
2	Average	1, Tough	15.0	60.5	23.0	0.5	(6)	80	18	Natural	No	None
411	do	Sample, Tough	14.5	58.5	25.0	.2	2.5	4	30	Musty	Yes	do

See footnotes at end of table.

in quality throughout bin and temperature data of wheat stored in experimental bins at and 1939—Continued

JUNE 29, 1937

Variations shown in other portions of bulk at same storage period								Admixtures	Harvest method or source of wheat	First "maximum" temperature period" in center of bulk [4]				Remarks
Moisture		Normal germination		Fat acidity [3]		Total damaged kernels				Initial temperature	"Final" temperature	Average temperature	Length of period	
Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum							
Pct.	*Pct.*	*Pct.*	*Pct.*	*Units*	*Units*	*Pct.*	*Pct.*			°*F.*	°*F.*	°*F.*	*Dy.*	
----	----	----	----	------	------	----	----	None	Commercial	82	94	86.0	42	
----	13.9	56	----	------	23	2.7	1.6	do	do	82	84	86.0	42	
15.1	12.2	64	9	37	23	8.0	1.0	do	do	82	94	86.0	42	Average sample 1 week before this was musty.
17.1	----	----	1	59	------	46.0	----	do	do	82	94	86.0	42	

JUNE 30, 1937

----	----	----	----	------	------	----	----	None	Combine	93	78	88.0	18	
----	12.6	88	----	------	12	----	0.3	do	do	93	78	88.0	18	Sample 18 inches from northeast wall. Top of bulk.
14.2	13.0	42	24	25	16	11.0	4.5	do	do	93	78	88.0	18	
14.1	12.8	82	3	40	16	18.0	3.0	do	do	93	78	88.0	18	

JUNE 30, 1937

----	----	----	----	------	------	----	----	None	Commercial	87	110	101.0	16	
14.3	----	9	4	54	42	----	7.0							

JUNE 30, 1937

15.1	14.7	35	14	33	30	7.0	0	None	Commercial	87	119	102.0	20	
14.4	14.1	8	----	55	47	----	8.0							

JUNE 30, 1937

15.2	----	34	20	33	------	----	0.2	None	Commercial	86	119	99.5	18	
----	14.0	----	1	56	------	----	5.5							

JULY 7, 1937

----	----	----	----	------	------	----	----	None	Commercial	89	73	79.5	12	Dried by elevating wheat.

JUNE 30, 1937

----	----	----	----	------	------	----	----	None	Commercial	83	74	78.0	10	

TABLE 37.—*Condition and quality of wheat, harvest method, admixtures, variations Hays, in 1936, 1937, 1938,*

Storage period when sampled (days)[1]	Portion of bulk sampled	Official grade of sample [2]	Moisture content	Test weight per bushel	Weight per 1,000 kernels	Dockage	Total damaged kernels	Normal germination	Fat acidity [3]	Odor	Fumigated	Weevil and other insect infestation
			Pct.	*Lb.*	*Gm.*	*Pct.*	*Pct.*	*Pct.*	*Units*			
BIN H-22, FILLED												
2	Average	Sample	15.6	60.5	27.0	0.5	0	64	22	Natural	No	None
41	do	do	15.8	57.5			6.0	19	32	Musty	No	do
61	do	do	15.7	57.7	26.0	.4	4.8	10	39	do	No	do
BIN H-23, FILLED												
1	Average	1	13.2	60.3	24.5	0.2	0	79	19	Natural	No	None
404	do	Sample	13.3	59.8	25.2	.1	3.5	3	29	Musty	Yes	do
BIN H-24, FILLED												
2	Average	1, Tough	15.0	60.4	24.5	0.2	(6)	82	18	Natural	No	None
182	do	Sample, Tough	15.1	58.0	26.0		1.5	1	28	Sour	Yes	do
411	do	do	14.7	57.7	24.0	.3	7.5	0	35	Musty	Yes	do
BIN H-25, FILLED												
1	Average	1	12.9	60.4	23.7	0.3	0.1	80	18	Natural	No	None
404	do	Sample	12.1	59.6	22.0	.1	0	13	30	Sour	Yes	do
421	do	do	12.1	59.8	24.3	.2	0	19	35	Musty	Yes	do
BIN H-26, FILLED												
2	Average	1, Tough	14.7	60.6	22.4	0.2	0	76	17	Natural	No	None
76	do	Sample	14.0	57.5			5.0	23	38	Musty	Yes	do
BIN H-27, FILLED												
2	Average	1, Tough	15.4	61.4	27.6	0.2	0	70	20	Natural	No	None
20	do	Sample, Tough	14.7	58.3			6.8	19	37	Musty	No	do
49	Inferior	Sample	15.9	55.0			18.0	4	64	do	No	do
BIN H-28, FILLED												
2	Average	3, Tough, Limed	15.4	57.3	26.6	0.5	(6)	63	21	Lime	No	None
69	do	Sample, Lime-sulfur	13.5	56.1	25.4		17.0	26	43	Musty	Yes	do
BIN H-29, FILLED												
8	Average	2, Tough, Limed	15.4	58.0	27.9	0.2	0	51	22	Lime	No	None
62	do	Sample, Tough, Limed.	15.3	56.0	27.0		20.0	8	53	Musty	Yes	Weevils

See footnotes at end of table.

in quality throughout bin and temperature data of wheat stored in experimental bins at and 1939—Continued

Variations shown in other portions of bulk at same storage period								Admixtures	Harvest method or source of wheat	First "maximum temperature period" in center of bulk [4]				Remarks
Moisture		Normal germination		Fat acidity[3]		Total damaged kernels								
Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum			Initial temperature	"Final" temperature	Average temperature	Length of period	
Pct.	*Pct.*	*Pct.*	*Pct.*	*Units*	*Units*	*Pct.*	*Pct.*			°*F.*	°*F.*	°*F.*	*Dy.*	
JUNE 30, 1937														
----	----	----	----	------	------	----	----	None	Commercial	84	82	76.8	54	
----	----	----	----	------	------	----	----							
----	----	----	----	------	------	----	----							
JULY 7, 1937														
----	----	----	----	------	------	----	----	None	Commercial	92	74	81.0	12	Dried by elevating wheat.
----	----	----	----	------	------	----	----							
JUNE 30,1937														
----	----	----	----	------	------	----	----	None	Commercial	84	74	78.0	10	
----	----	----	----	------	------	----	----							
----	----	----	----	------	------	----	----							
JULY 7, 1937														
----	----	----	----	------	------	----	----	None	Commercial	93	90	87.2	34	Dried by running through elevator.
13.0	11.4	----	6	------	29	----	----							
JUNE 30, 1937														
----	----	----	----	------	------	----	----	None	Commercial	87	98	90.0	42	About 6 inches of spoiled wheat on bottom.
----	----	----	----	------	------	----	----	do	do	87	89	90.0	42	
JUNE 30, 1937														
----	----	----	----	------	------	----	----	None	Commercial	86	102	99.0	42	
----	----	----	----	------	------	----	----							
----	14.0	29	----	------	46	----	7.0							
JUNE 30, 1937														
----	----	----	----	------	------	----	----	Lime-sulfur	Commercial	82	102	90.2	42	Somewhat caked and very musty.
----	----	----	----	------	------	----	----		do	82	102	90.2	42	
JUNE 30, 1937														
16.4	----	----	2	67	------	45.0	----	Lime-sulfur	Commercial	83	99	92.0	42	

TABLE 37.—*Condition and quality of wheat, harvest method, admixtures, variations Hays, in 1936, 1937, 1938,*

Storage period when sampled (days) [1]	Portion of bulk sampled	Official grade of sample [2]	Moisture content	Test weight per bushel	Weight per 1,000 kernels	Dockage	Total damaged kernels	Normal germination	Fat acidity [3]	Odor	Fumigated	Weevil and other insect infestation
			Pct.	*Lb.*	*Gm.*	*Pct.*	*Pct.*	*Pct.*	*Units*			
BIN H-30, FILLED												
2	Average	1, Tough	15.3	60.8	25.9	0.9	(6)	66	20	Natural	No	None
51+11	do	Sample, Tough	14.2	57.2			5.0	9	50	Musty	Yes	Weevils
51+24	do	do	14.1	57.5	25.0		9.0	1	63	do	Yes	None
BIN H-31, FILLED												
2	Average	1, Tough	14.8	60.4	25.0	0.2	0	79	19	Natural	No	None
69	do	Sample	14.0	57.6			2.0	22	39	Musty	Yes	Weevils
BIN H-32, FILLED												
2	Average	1, Tough	14.9	60.7	25.2	0.2	0	82	18	Natural	No	None
69	do	Sample, Tough	14.2	57.7			2.4	26	35	Musty	Yes	do
BIN H-33, FILLED												
2	Average	1, Tough	15.4	61.2	25.4	0.2	0	69	20	Natural	No	None
73	do	3	12.6	59.3	26.0		5.0	45	29	do	Yes	do
BN H-2, FILLED												
2	Average	4	10.2	54.8	24.0	0.3	0	[7] 81	[7] 11	Natural	No	None
477	do	4	9.8	54.8		.2		92	13	do	Yes	do
BIN H-5, FILLED												
5	Average	3	13.0	56.8	23.5	1.0	0	[7] 87	[7] 11	Natural	No	None
578	do	3	12.1	57.0		.4	0	94	19	do	Yes	do
992	do	3	11.9	56.7		.4	.8			do	Yes	do
BIN H-6, FILLED												
2	Average	Sample	16.2	54.1	24.0	0.8	0	[7] 84	[7] 11	Natural	No	None
34	do	3	12.4	56.0		.9	0	[7] 84	[7] 16	do	Yes	do
580	do	4	11.6	55.7		.6	0	87	19	do	Yes	do
740	do	4	11.6	55.8		1.0	(6)	88	21	do	Yes	Insects
740+253	do	3	11.8	56.0		.8	1.0			do	Yes	None

See footnotes at end of table.

in quality throughout bin and temperature data of wheat stored in experimental bins at and 1939—Continued

Variations shown in other portions of bulk at same storage period								Admixtures	Harvest method or source of wheat	First "maximum" temperature period" in center of bulk [4]				Remarks
Moisture		Normal germination		Fat acidity[3]		Total damaged kernels				Initial temperature	"Final" temperature	Average temperature	Length of period	
Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum							
Pct.	*Pct.*	*Pct.*	*Pct.*	*Units*	*Units*	*Pct.*	*Pct.*			°*F.*	°*F.*	°*F.*	*Dy.*	
JUNE 30, 1937														
----	----	----	----	----	----	----	----	Peat in sacks	Commercial	83	102	91.2	43	
JUNE 30, 1937														
----	----	----	----	----	----	----	----	None	Commercial	85	100	89.0	65	
----	----	----	----	----	----	----	----	do	do	85	100	89.0	65	About 6 inches of spoiled wheat in bottom when emptied.
JUNE, 30 1937														
----	----	----	----	----	----	----	----	None	Commercial	85	93	87.0	44	
JUNE 30, 1937														
----	----	----	----	----	----	----	----	None	Commercial	79	84	79.0	58	
JULY 6, 1938														
12.0	9.1	86	74	12	9	----	----	None	Combine	100	91	91.5	44	
10.4	8.6	94	87	16	11	----	----							
JUNE 30, 1939														
14.0	12.4	93	86	14	9	----	----	None	Commercial	86	77	77.0	63	Some musty wheat under filling door Aug. 1, 1939, and weevily wheat Sept. 18, 1939.
14.0	10.5	97	66	24	17	(6)	----							
----	----	----	----	----	----	----	----							
JUNE 28, 1938														
16.7	15.6	88	79	13	10	----	----	None	Commercial	85	87	84.2	58	
15.8	10.1	88	82	18	13	----	----	do	do	85	87	84.2	58	End of forced ventilation.
12.8	9.7	94	83	21	15	(6)	----	do	do	85	87	84.2	58	
14.5	11.3	----	----	35	18	----	----	do	do	85	87	84.2	58	
----	----	----	----	----	----	----	----	do	do	85	87	84.2	58	10 insects injurious to stored grain were found in bottom sample.

TABLE 37.—*Condition and quality of wheat, harvest method, admixtures, variations Hays, in 1936, 1937, 1938,*

Storage period when sampled (days) [1]	Portion of bulk sampled	Official grade of sample [2]	Moisture content	Test weight per bushel	Weight per 1,000 kernels	Dockage	Total damaged kernels	Normal germination	Fat acidity [3]	Odor	Fumigated	Weevil and other insect infestation
			Pct.	*Lb.*	*Gm.*	*Pct.*	*Pct.*	*Pct.*	*Units*			
BIN H-7, FILLED												
1	Average	3	13.8	57.0	23.4	0.4	0	[7] 83	[7] 12	Natural	No	None
32	do	3	10.7	56.7		.4	0	[7] 84	[7] 15	do	Yes	do
135	do	3	[7] 10.4	56.9	23.8	.6	.6	87	16	do	Yes	do
BIN H-8, FILLED												
154+577 +9	Average	3	11.3	56.1	22.0	0.5	1.1	[7] 63	[7] 20	Natural	No	None
154+577 +580	do	4	12.0	55.7		.5	(6)	72	23	do	Yes	Weevils
154+577 +994	do	3	11.9	56.0		.4	0			do	Yes	None
BIN H-10, FILLED												
4	Average	3, Tough	14.4	57.5	22.6	0.5	0	[7] 85	[7] 11	Natural	No	None
31	do	3	13.3	57.7		.5	0	[7] 90	[7] 19	do	Yes	do
578	do	3	11.0	57.0		.7	0	91	19	do	Yes	Insects
991	do	3	12.3	57.1		.6	(6)			do	Yes	None
BIN H-11, FILLED												
4	Average	3, Tough	[7] 14.7	57.5	24.0	0.7	0	[7] 90	[7] 11	Natural	No	None
31	do	3	13.0	57.7		.5	0	[7] 86	[7] 19	do	Yes	do
218	do	3	[7] 12.6	57.2		.8	(6)	87	19	do	Yes	do
BIN H-12, FILLED												
4	Average	3, Tough	14.5	57.5	24.0	0.6	0	[7] 87	[7] 13	Natural	No	None
31	do	3	12.7	57.7		.5	0	[7] 86	[7] 18	do	Yes	do
578	do	3	11.9	57.0		.6	0	91	20	do	Yes	Insects
991	do	3	12.2	57.1		.6	0			do	Yes	do
BIN H-26, FILLED												
6	Average	3	13.0	56.8	23.5	1.0	0	87	11	Natural	No	None
580	do	3	12.8	56.0		.7		35	25	do	Yes	do
673	do	Sample	12.7	55.6		.5	2.0	56	26	Musty	Yes	do

See footnotes at end of table.

in quality throughout bin and temperature data of wheat stored in experimental bins at and 1939—Continued

JUNE 30, 1938

Variations shown in other portions of bulk at same storage period								Admixtures	Harvest method or source of wheat	First "maximum" temperature period" in center of bulk [4]				Remarks
Moisture		Normal germination		Fat acidity [3]		Total damaged kernels				Initial temperature	"Final" temperature	Average temperature	Length of period	
Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum							
Pct.	*Pct.*	*Pct.*	*Pct.*	*Units*	*Units*	*Pct.*	*Pct.*			°*F.*	°*F.*	°*F.*	*Dy.*	
14.3	13.0	88	80	14	10	----	----	None	Commercial	86	92	83.5	50	
11.0	10.3	88	82	18	14	----	----	do	do	86	92	83.5	50	End of forced ventilation.
11.0	9.8	91	84	16	14	0.7	----	do	do	86	92	83.5	50	

JUNE 28, 1938

12.6	10.8	66	58	21	19	----	----	None	Combine	78	80	78.8	62	Wheat from 1936 crop in bin H–5.
14.2	9.9	81	6	37	21	0.4	0	do	do	78	80	78.8	62	Some spoiled wheat having musty odor and weevils found Sept. 18, 1939, under roof filling door at positions 1 and 4.
----	----	----	----	----	----	----	----	do	do	78	80	78.8	62	

JULY 1, 1938

15.0	14.2	89	82	13	11	----	----	None	Commercial	83	78	78.0	40	
14.6	13.1	94	87	20	17	----	----							
11.6	10.5	94	87	21	18	----	----							
----	----	----	----	----	----	----	----							

JULY 1, 1938

15.0	13.8	93	86	13	11	----	----	None	Commercial	84	81	81.0	49	
14.5	12.4	91	----	20	17	----	----							
13.4	11.6	90	79	20	17	0.3	----							

JULY 1, 1938

15.2	13.8	89	86	13	12	----	----	None	Commercial	83	81	80.0	49	
14.9	----	91	83	19	17	----	----							
12.3	10.6	93	86	23	18	----	----							
----	----	----	----	----	----	----	----							

JUNE 29, 1938

----	----	----	----	----	----	----	----	None	Commercial	92	85	87.0	44	Comprises part of each load stored in bin H–5.
----	----	----	----	----	----	----	----	do	do	92	85	87.0	44	
----	----	----	----	----	----	----	----	do	do	92	85	87.0	44	

TABLE 37.—*Condition and quality of wheat, harvest method, admixtures, variations Hays, in 1936, 1937, 1938,*

Storage period when sampled (days)[1]	Portion of bulk sampled	Official grade of sample [2]	Moisture content	Test weight per bushel	Weight per 1,000 kernels	Dockage	Total damaged kernels	Normal germination	Fat acidity [3]	Odor	Fumigated	Weevil and other insect infestation
			Pct.	*Lb.*	*Gm.*	*Pct.*	*Pct.*	*Pct.*	*Units*			
BIN H-29, FILLED												
2	Average	4	10.2	54.8	24.0	0.3	0	81	11	Natural	No	None
578	do	4	10.5	54.0		.2		89	16	do	Yes	do
BIN H-41, FILLED												
2	Average	4	10.3	55.0	23.5	0.3			[7] 12	Natural	No	None
213	do	Sample	[7] 10.9	54.3		.3	0	[7] 81	17	Musty	Yes	do
344	do	do	12.0	54.0		.3	0	79	18	do	Yes	do
							(6)	78				
BIN H-42, FILLED												
2	Average	3	[7] 13.0	57.2	24.3	0.4	0	[7] 88	[7] 12	Natural	No	None
220	do	Sample	[7] 13.8	56.6		.4	.8	60	23	Musty	Yes	do
251+310	do	do	14.6	55.8		.4	1.2	26	31	Sour	Yes	do
BIN H-41, FILLED												
2	Average	1 [8]	13.0	60.2	26.6	0.2	0	[7] 93	[7] 13	Natural	No	None
215	do	2 [8]	12.1	59.5		.3	0	94	16	do	Yes	do
629	do	Sample [8]	13.1	58.2		.5	(6)			(Rodent) musty.	Yes	do
BIN H-44, FILLED												
3	Average	Sample [8]	15.7	58.7	30.0	0.2	0	[7] 78	[7] 18	Natural	No	None
35	do	2 [8]	10.1	59.4		.2	(6)	71	20	do	No	do
216	do	2 [8]	10.6	59.5		.1	1.5	79	21	do	Yes	do
406	do	Sample [8]	11.6	59.4		.1	3.0			COFO [9]	Yes	do
630	do	2 [8]	11.7	59.3		.1	1.7			Natural	Yes	do

[1] Plus sign (+) indicates that grain was moved after previous sampling. Total storage period for any sample is sum of figures, added horizontally.
[2] All wheat of class Hard Red Winter and subclass Dark Hard Winter except where noted.
[3] Fat acidity for all samples drawn in 1936 was calculated from the acid value determination and average oil content of hard red winter wheat.

in quality throughout bin and temperature data of wheat stored in experimental bins at and 1939—Continued

Variations shown in other portions of bulk at same storage period								Admixtures	Harvest method or source of wheat	First "maximum temperature period" in center of bulk [4]				Remarks
Moisture		Normal germination		Fat acidity[3]		Total damaged kernels				Initial temperature	"Final" temperature	Average temperature	Length of period	
Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum							
Pct.	*Pct.*	*Pct.*	*Pct.*	*Units*	*Units*	*Pct.*	*Pct.*			°*F.*	°*F.*	°*F.*	*Dy.*	
JULY 6, 1938														
----	----	----	----	------	------	----	----	None	Combine	84	83	85.0	37	Same as wheat in H-2.
JULY 6, 1938														
11.8	8.7	87	78	14	9	----	----	None	Combine	95	93	93.5	56	
13.0	9.1	88	60	18	14	(6)	----	do	do	95	93	93.5	56	
17.8	9.3	86	0	------	15	100	----	do	do	95	93	93.5	56	Inferior portion caked moldy wheat against wall of bin 3 feet below top surface.
JUNE 29, 1938														
14.3	12.2	90	84	14	10	----	----	None	Commercial	85	86	86.0	32	
18.2	12.8	89	4	36	17	2.5	----	do	do	85	86	86.0	32	Moldy wheat against walls of bin.
17.4	12.8	53	1	45	25	1.7	1.0	do	do	85	86	86.0	32	Special wall treatments installed Mar. 7, 1938, and wheat replaced Mar. 25, 1939.
JUNE 28, 1939														
13.6	----	94	91	15	13	----	----	None	Combine	82	85	77.5	48	
12.9	10.6	96	88	17	13	----	----	do	do	82	85	77.5	48	
----	----	----	----	------	------	----	----	do	do	82	85	77.5	48	Middle and bottom portions had a natural odor.
JUNE 27, 1939														
16.1	----	88	71	20	15	----	----	None	Commercial	84	92	82.5	29	
13.2	8.6	----	47	24	19	----	----	do	do	84	92	82.5	29	
12.9	8.9	----	61	24	20	1.7	----	do	do	84	92	82.5	29	
----	----	76	54	------	------	----	----	do	do	84	92	82.5	29	
----	----	----	----	------	------	----	----	do	do	84	92	82.5	29	Slight chemical odor.

[4] Ordinarily if newly harvested wheat heats in the bin it is during the initial storage period. The temperature data given are for only the period stated in the length of period column.
[5] Estimated moisture (interpolated).
[6] Trace.
[7] Composite averages.
[8] Wheat of class Hard Red Winter and subclass Hard Winter.
[9] Commercially objectionable foreign odor.

TABLE 38.—*Description of experimental bins filled at College Park in 1936, 1937, and 1938*

BINS FILLED IN 1936

Bin Number	Location of bin	Roof type	Bin surfaces contacting wheat				Bulk aeration			Bulk measurements		
			Floor—material	Walls			Type	Air paths through bulk		Quantity	Average depth	Half minimum width
				Material	Number exposed to sun	Resistance to heat transfer [1]		Average	Range			
								Feet	*Feet*	*Bushels*	*Feet*	*Feet*
B-1	Outdoors	Metal	Wood	Metal	3	0.7	None	0	0	236	7.5	5.0
B-2		do	Concrete	do	3	.7	do	0	0	236	7.5	5.0
B-3		Insulated metal	Wood	Wallboard lining	0	3.12	do	0	0	228	7.5	4.8
B-4		do	do	do	0	3.12	do	0	0	209	7.0	4.8
B-5		Roll	do	Wood	3	1.68	do	0	0	271	7.0	5.0
B-6		do	do	do	3	1.68	Forced (wind)	2.8	4.4	255	6.6	5.0
B-7		do	do	do	3	3.57	None	0	0	271	7.0	5.0
B-8		do	do	do	3	3.57	Ducts	2.8	4.4	255	6.6	5.0
B-9		Wallboard	Insulated metal	Insulated metal	(2)	10.69	None	0	0	20	2.8	1.6
B-10		do	do	do	(2)	10.69	do	0	0	20	2.8	1.6
B-11		do	do	do	(2)	10.69	do	0	0	20	2.8	1.6
B-12		do	do	do	(2)	10.69	do	0	0	12	3.0	1.6
B-13		do	do	do	(2)	10.69	do	0	0	20	2.8	1.6
B-14		Metal	Metal	Metal	(2)	.7	do	0	0	20	2.8	1.6
B-15		do	do	do	(2)	.7	do	0	0	18	3.0	1.6
B-16		do	do	do	(2)	.7	do	0	0	20	2.8	1.6
B-17		do	do	do	(2)	.7	do	0	0	20	2.8	1.6
B-18		do	do	do	(2)	.7	do	0	0	20	2.8	1.6

BINS FILLED IN 1937

B-1	Outdoors	Metal	Wood	Metal	3	0.7	None	0	0	190	5.3	5.0
B-2		Insulated metal	Concrete	Wallboard lining	0	3.12	do	0	0	186	6.2	4.8
B-3	Open shed	Metal canopy	Wood	Metal	(3)	.7	do	0	0	165	5.2	5.0
B-4		do	do	do	(3)	.7	do	0	0	186	6.0	5.0
B-5	Outdoors	Roll	do	Wood	0	1.68	do	0	0	240	6.2	5.0
B-6		do	do	do	3	1.68	Forced (wind)	1.0	.2	266	6.8	5.0
B-7		do	Perforated metal	do	3	3.57	Power	2.2	4.8	266	6.6	5.0
B-8		do	Wood	do	3	3.57	None	0	0	230	5.8	5.0
B-10		Wallboard	Insulated metal	Insulated metal	(2)	10.69	do	0	0	20	2.8	1.6
B-11		do	do	do	(2)	10.69	do	0	0	20	2.8	1.6
B-12		do	Metal	Metal	(2)	.7	do	0	0	15	3.2	1.9
B-13		do	do	do	[4] 0	.7	do	0	0	25	2.7	1.9
B-14		Metal	do	do	(2)	.7	do	0	0	18	2.8	1.6
B-15		do	do	do	(2)	.7	do	0	0	20	2.8	1.6
B-16		do	do	do	(2)	.7	do	0	0	20	2.8	1.6
B-17		do	do	do	(2)	.7	do	0	0	20	2.8	1.6
B-19		do	do	do	(2)	.7	do	0	0	22	6.8	1.1
B-20		do	do	do	(2)	.7	do	0	0	22	6.8	1.1
B-21		do	do	do	(2)	.7	do	0	0	20	2.8	1.6
B-22		do	do	do	(2)	.7	do	0	0	20	2.8	1.6
B-23		do	do	do	(2)	.7	Forced (wind)	1.0	.2	24	7.8	1.1
B-24		do	do	do	(2)	.7	do	1.0	.2	24	7.8	1.1
B-25	Open shed	Metal canopy	do	do	(3)	.7	None	0	0	189	5.7	5.0
B-26		do	do	do	(3)	.7	do	0	0	180	5.7	5.0

BINS FILLED IN 1938

B-27	Granary	Metal	Wood	Wood	2	1.40	None	0	0	390	8.3	3.4
B-28		do	do	do	2	1.40	do	0	0	380	7.8	3.6
B-29A	Outdoors	do	do	Metal	(2)	.7	do	0	0	400	7.0	5.0
B-29	Granary	do	do	Wood	2	1.40	do	0	0	383	8.2	3.6
B-30		do	do	do	2	1.40	do	0	0	396	8.9	3.4

[1] Resistance or degrees Fahrenheit difference in temperature on opposite surfaces of wall which will cause 1 B. t. u. of heat to pass through an area of 1 square foot in 1 hour.
[2] All walls supporting wheat exposed to sun.
[3] Portion of one wall exposed to sun.
[4] Shaded by aluminum foil paper supported 3 inches away from metal wall by furring strips.

TABLE 39.—*Condition and quality of wheat, harvest method, admixtures, variations at College Park, in*

Storage period when sampled (days)[1]	Portion of bulk sampled	Official grade of sample [2]	Moisture content	Test weight per bushel	Weight per 1,000 kernels	Dockage	Total damaged kernels	Normal germination	Fat acidity [3]	Odor	Fumigated	Weevil and other insect infestation
			Pct.	*Lb.*	*Gm.*	*Pct.*	*Pct.*	*Pct.*	*Units*			
BIN B-1, FILLED												
0	Average	Sample, Garlicky	16.4	59.0	37.2	0.2	0.5	87	18	Natural	No	None
27	do	do	16.2	54.7	35.6	.3	22.7	12		Sour	No	do
BIN B-2, FILLED												
0	Average	Sample, Garlicky	16.4	59.0	37.2	0.2	0.5	87	18	Natural	No	None
25	do	do	16.2	56.0	36.2	.2	20.3	14		Sour	No	do
BIN B-3, FILLED												
0	Average	Sample, Garlicky	16.5	59.0	38.5	0.2	0.3	90	17	Natural	No	None
31	do	do	16.1	56.3	35.9		28.7	20		Sour	No	do
BIN B-4, FILLED												
0	Average	Sample, Garlicky	16.5	95.0	38.5	0.2	0.3	90	17	Natural	No	None
30	do	do	16.2	56.0	36.8		23.5	23		Sour	No	do
BIN B-5, FILLED												
0	Average	Sample, Garlicky	16.5	59.0	37.3	0.2	0.4	94	18	Natural	No	None
29	do	do	16.1	56.0	36.5		37.5	24		Sour	No	do
BIN B-6, FILLED												
0	Average	Sample, Garlicky	16.5	59.0	37.3	0.2	0.4	94	18	Natural	No	None
69	do	Sample, Garlicky, Tough.	15.3	54.0	36.0	.2	18.3	0		Sour	No	do
BIN B-7, FILLED												
0	Average	Sample, Garlicky	16.4	59.0	37.8	0.2	0.2	83	17	Natural	No	None
34	do	do	16.4	56.8	35.7		17.8	48		Sour	No	do

See footnotes at end of table.

in quality throughout bin and temperature data of wheat stored in experimental bins 1936, 1937, and 1938

Variations shown in other portions of bulk at same storage period								Admixtures	Harvest method or source of wheat	First "maximum temperature period" in center of bulk [4]				Remarks
Moisture		Normal germination		Fat acidity [3]		Total damaged kernels				Initial temperature	"Final" temperature	Average temperature	Length of period	
Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum							
Pct.	*Pct.*	*Pct.*	*Pct.*	*Units*	*Units*	*Pct.*	*Pct.*			°*F.*	°*F.*	°*F.*	*Dy.*	
JULY 10, 1936														
---	---	---	---	---	---	---	---	None	Commercial	88	120	97.0	26	Heat-damaged kernels 0.3 percent. Moldy sprouted.
---	---	---	---	---	---	---	---	do	do	88	120	97.0	26	
JULY 11, 1936														
---	---	---	---	---	---	---	---	None	Commercial	86	119	96.5	25	Heat-damaged kernels 0.1 percent. Moldy, sprouted, and scabby.
---	---	---	0	---	---	---	---	do	do	86	119	96.5	25	
JULY 11, 1936														
---	---	---	---	---	---	---	---	None	Commercial	86	115	94.0	29	Heat-damaged kernels 0.2 percent. Moldy sprouted.
---	---	---	7	---	---	---	---	do	do	86	115	94.0	29	
JULY 11, 1936														
---	---	---	---	---	---	---	---	None	Commercial	85	121	98.4	29	Heat-damaged kernels 0.1 percent. Moldy sprouted.
---	---	---	12	---	---	---	---	do	do	85	121	98.4	29	
JULY 10, 1936														
---	---	---	---	---	---	---	---	None	Commercial	85	119	97.0	28	Heat-damaged kernels 0.1 percent. Moldy sprouted.
---	---	---	15	---	---	---	---	do	do	85	119	97.0	28	
JULY 10, 1936														
---	---	---	---	---	---	---	---	None	Commercial	88	112	91.0	41	Heat-damaged kernels 0.1 percent. Moldy sprouted.
---	---	12	---	---	---	---	---	do	do	88	112	91.0	41	
JULY 10, 1936														
---	---	---	---	---	---	---	---	Non	Commercial	87	120	94.5	33	Heat-damaged kernels 0.1 percent. Moldy sprouted.
---	---	---	21	---	---	---	---	do	do	87	120	94.5	33	

TABLE 39.—*Condition and quality of wheat, harvest method, admixtures, variations at College Park, in 1936,*

Storage period when sampled (days)[1]	Portion of bulk sampled	Official grade of sample [2]	Moisture content	Test weight per bushel	Weight per 1,000 kernels	Dockage	Total damaged kernels	Normal germination	Fat acidity [3]	Odor	Fumigated	Weevil and other insect infestation
			Pct.	*Lb.*	*Gm.*	*Pct.*	*Pct.*	*Pct.*	*Units*			
BIN B-8, FILLED												
0	Average	Sample, Garlicky	16.4	59.0	37.8	0.2	0.2	83	17	Natural	No	None
69	do	Sample, Garlicky, Tough.	15.2	55.6	35.9	.3	4.2	41		Sour	No	do
BIN B-9, FILLED												
0	Average	2	11.4	58.6	37.4	0.2	0.1	88		Natural	No	None
1,019	do	3	12.0	57.5			2.5	37	27	do	Yes	do
1,231	do	3	12.1	57.2			2.9	18	30	do	Yes	Weevils
BIN B-10, FILLED												
0	Average	4, Garlicky, Tough	15.0	56.7	35.8	0.5	7.7	92		Natural	No	None
320	do	do	14.7	57.2	35.4	.5	8.9	60		do	No	do
BIN B-11, FILLED												
0	Average	Sample, Garlicky	15.7	57.6	36.4	0.2	1.9	95		Natural	No	None
316	do	3, Garlicky, Tough	15.4	57.3	36.3	.3	2.6	35		do	No	do
BIN B-12, FILLED												
0	Average	Sample, Garlicky	18.0	56.2	34.4	1.1	1.9	92		Natural	No	None
59	do	Sample, Garlicky, Tough.	14.4	56.4	34.8	1.1	45.0	15		Sour	No	do
BIN B-13, FILLED												
0	Average	Sample, Garlicky	16.4	59.0	37.5	0.2	0.3	91		Natural	No	None
326	do	2, Garlicky, Tough	15.0	58.0	37.1	.2	.4	47		do	No	Insects
BIN B-14, FILLED												
0	Average	Sample, Garlicky	16.4	59.0	37.6	0.2	0.4	88		Natural	No	None
326	do	3, Garlicky, Tough	14.1	57.3	37.3	.2	.5	38		do	No	Insects
BIN B-15, FILLED												
0	Average	Sample, Garlicky	17.9	56.2	33.6	0.9	1.7	98		Natural	No	None
59	do	Sample, Garlicky, Tough.	14.2	56.3	33.8	.9	36.0	0		Sour	No	do

See footnotes at end of table.

in quality throughout bin and temperature data of wheat stored in experimental bins 1937, and 1938—Continued

Variations shown in other portions of bulk at same storage period								Admixtures	Harvest method or source of wheat	First "maximum temperature period" in center of bulk [4]				Remarks
Moisture		Normal germination		Fat acidity [2]		Total damaged kernels								
Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum			Initial temperature	"Final" temperature	Average temperature	Length of period	
Pct.	*Pct.*	*Pct.*	*Pct.*	*Units*	*Units*	*Pct.*	*Pct.*			°*F.*	°*F.*	°*F.*	*Dy.*	
JULY 10, 1936														
----	----	----	----	----	----	----	----	None	Commercial	84	113	92.8	39	
----	----	----	0	----	----	----	----							
JULY 16, 1936														
----	----	----	----	----	----	----	----	None	Commercial	85	84	82.0	39	
----	11.6	----	21	34	----	----	----							
----	11.4	53	14	58	24	----	----							
JULY 16, 1936														
----	----	----	----	----	----	----	----	None	Commercial	81	83	81.3	42	
----	----	----	----	----	----	----	----							
JULY 20, 1936														
----	----	----	----	----	----	----	----	None	Commercial	80	82	80.0	38	
----	----	----	----	----	----	----	----							
JULY 20, 1936														
----	----	----	----	----	----	----	----	Peat	Commercial	81	122	92.5	50	
----	----	----	----	----	----	----	----	do	do	81	122	92.5	50	Heat-damaged kernels, "trace."
JULY 10, 1936														
----	----	----	----	----	----	----	----	None	Commercial	86	84	82.5	68	
----	----	----	----	----	----	----	----							
JULY 10, 1936														
----	----	----	----	----	----	----	----	None	Commercial	87	87	83.2	68	
----	----	----	----	----	----	----	----							
JULY 20, 1936														
----	----	----	----	----	----	----	----	Peat	Commercial	80	118	89.9	34	
----	----	----	----	----	----	----	----	do	do	80	118	89.9	34	Heat-damaged kernels, "trace."

TABLE 39.—*Condition and quality of wheat, harvest method, admixtures, variations at College Park, in 1936,*

Storage period when sampled (days) [1]	Portion of bulk sampled	Official grade of sample [2]	Moisture content	Test weight per bushel	Weight per 1,000 kernels	Dockage	Total damaged kernels	Normal germination	Fat acidity [3]	Odor	Fumigated	Weevil and other insect infestation
			Pct.	*Lb.*	*Gm.*	*Pct.*	*Pct.*	*Pct.*	*Units*			
BIN B-16, FILLED												
0	Average	Sample, Garlicky	15.7	57.8	36.4	0.2	1.7	93	------	Natural	No	None
172	do	3, Garlicky, Tough	15.3	56.9	36.0	.2	2.3	61	------	do	No	Insects
BIN B-17, FILLED												
0	Average	4, Garlicky, Tough	15.0	56.4	34.8	0.6	9.8	94	------	Natural	No	None
320	do	4, Garlicky	13.5	56.0	34.8	.6	9.9	81	------	do	No	Insects
BIN B-18, FILLED												
0	Average	2	11.3	58.7	37.6	0.3	0.2	82	------	Natural	No	None
1,019	do	3	13.1	57.5	-----	----	2.6	34	28	do	Yes	do
1,154	do	Sample	13.0	56.4	-----	----	4.5	4	40	Sour	Yes	Weevils
1,231	do	do	13.4	56.5	-----	----	5.5	15	37	do	Yes	do
BIN B-1, FILLED												
0	Average	3, Garlicky, Tough	14.6	56.7	35.2	0.2	2.9	90	20	Natural	No	None
73	Inferior	Sample, Garlicky	16.7	52.5	35.8	.3	7.2	11	60	Musty	No	do
148	Average	Sample, Garlicky, Tough.	15.0	54.8	-----	----	3.7	38	26	do	No	Weevils
BIN B-2, FILLED												
0	Average	3, Garlicky, Tough	14.6	56.8	35.2	0.2	2.8	93	17	Natural	No	None
42	do	Sample, Garlicky, Tough.	14.8	56.3	-----	----	3.2	72	23	Musty	No	do
73	Inferior	do	15.5	53.2	35.0	----	8.2	24	31	Sour	No	Weevils
348	Average	do	15.1	54.8	-----	----	4.8	19	38	do	Yes	do
BIN B-3, FILLED												
0	Average	3, Garlicky, Tough	14.2	57.4	33.4	0.2	2.9	91	14	Natural	No	None
274	do	Sample, Garlicky, Tough.	14.4	56.3	-----	----	3.0	73	23	Sour	Yes	do
516	do	do	14.5	54.7	-----	----	4.0	1	45	do	Yes	do
BIN B-4, FILLED												
0	Average	3, Garlicky, Tough	14.7	56.8	35.1	0.2	2.9	89	17	Natural	No	None
274	do	Sample, Garlicky, Tough.	14.7	56.0	-----	----	3.0	58	24	Sour	Yes	do
368	do	do	14.8	55.2	-----	----	3.4	7	36	do	Yes	do

See footnotes at end of table.

in quality throughout bin and temperature data of wheat stored in experimental bins 1937, and 1938—Continued

JULY 20, 1936

Variations shown in other portions of bulk at same storage period								Admixtures	Harvest method or source of wheat	First "maximum temperature period" in center of bulk [4]				Remarks
Moisture		Normal germination		Fat acidity [3]		Total damaged kernels				Initial temperature	"Final" temperature	Average temperature	Length of period	
Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum							
Pct.	*Pct.*	*Pct.*	*Pct.*	*Units*	*Units*	*Pct.*	*Pct.*			°*F.*	°*F.*	°*F.*	*Dy.*	
----	----	----	----	------	------	----	----	None	Commercial	79	85	83.0	38	
----	----	----	----	------	------	----	----							

JULY 16, 1936

----	----	----	----	------	------	----	----	None	Commercial	82	87	83.5	36	
----	----	----	----	------	------	----	----							

JULY 16, 1936

----	----	----	----	------	------	----	----	None	Commercial	85	85	83.0	42	
13.6	12.8	46	----	30	27	----	----	do	do	85	85	83.0	42	
----	----	----	----	------	------	----	----	do	do	85	85	83.0	42	Bottom probes tough.
25.5	11.5	46	0	43	27	----	----	do	do	85	85	83.0	42	Bottom 3 inches wet and rotted wheat.

JULY 23, 1937

----	14.5	92	84	22	14	----	2.8	None	Commercial	82	86	82.5	29	Inferior portion consisted of about 20 bushels directly under roof filling door.
----	14.4	84	----	------	20	----	2.9							
18.3	14.5	60	11	51	21	11.6	3.2							

JULY 23, 1937

14.7	----	95	91	------	14	2.9	----	None	Commercial	82	85	82.0	31	Inferior portion consisted of about 20 bushels directly under roof filling door.
----	14.7	82	71	------	21	----	3.0							
----	14.6	81	----	------	20	----	3.0							
17.0	14.7	50	2	56	26	12.3	4.4							

JULY 23, 1937

14.3	----	----	82	19	------	----	----	None	Commercial	82	80	80.0	31	
----	14.2	74	62	24	22	----	----	do	do	82	80	80.0	31	Fat acidity was interpolated.
16.1	13.2	10	0	57	30	----	3.9	do	do	82	80	80.0	31	

JULY 22, 1937

14.8	----	92	88	------	13	3.0	----	None	Commercial	78	80	79.1	33	
14.8	----	61	57	------	23	----	2.9	do	do	78	80	79.1	33	Fat acidity was interpolated.
15.5	13.7	67	0	43	26	3.5	3.0	do	do	78	80	79.1	33	

TABLE 39.—*Condition and quality of wheat, harvest method, admixtures, variations at College Park, in 1936,*

Storage period when sampled (days) [1]	Portion of bulk sampled	Official grade of sample [2]	Moisture content	Test weight per bushel	Weight per 1,000 kernels	Dockage	Total damaged kernels	Normal germination	Fat acidity [3]	Odor	Fumigated	Weevil and other insect infestation
			Pct.	*Lb.*	*Gm.*	*Pct.*	*Pct.*	*Pct.*	*Units*			
BIN B-5, FILLED												
1	Average	3, Garlicky, Tough	14.6	56.7	35.2	0.2	2.9	89	19	Natural	No	None
275	do	Sample, Garlicky, Tough.	14.7	56.0			3.4	57	25	Sour	Yes	do
365	do	do	14.7	55.8			3.9	15	30	do	Yes	do
BIN B-6, FILLED												
2	Average	3, Garlicky, Tough	15.1	57.8	35.8	0.3	1.8	92	15	Natural	No	None
520	do	2, Garlicky	13.4	58.5			2.7	57	26	do	Yes	do
863	do	3, Garlicky, Weevily.	13.4	57.8			3.9	48	31	do	Yes	Weevils
1,325	do	3, Garlicky, Weevily.	13.4	57.5			4.8	28	36	do	Yes	Insects
BIN B-7 FILLED												
0	Average	3, Garlicky, Tough	15.1	57.6	35.6	0.3	1.7	86	19	Natural	No	None
520	do	2, Garlicky	13.6	58.0			2.8	41	29	do	Yes	do
863	do	3, Garlicky	13.0	57.5			3.8	28	35	do	Yes	Weevils
1,325	do	3, Garlicky, Weevily.	13.0	57.0			5.8	2	43	do	Yes	do
BIN B-8, FILLED												
1	Average	3, Garlicky, Tough, Limed.	15.1	56.4	35.4	0.3	1.8	91	18	Natural	No	None
366	do	4, Garlicky, Tough, Limed.	14.9	55.0			2.8	28	32	do	Yes	Insects
785	do	4, Garlicky, Limed, Weevily.	14.0	55.0			4.5	1	50	do	Yes	Weevils
1,324	do	4, Garlicky, Limed, Weevily.	13.7	54.8			8.5	0	68	do	Yes	do
BIN B-10, FILLED												
0	Average	3, Garlicky, Tough	14.6	56.4	35.0	0.2	2.9	86	16	Natural	No	None
175+14	do	3, Garlicky, Tough	14.9	56.0			3.0	64	24	do	Yes	do
175+189	do	Sample, Garlicky, Tough.	14.5	54.6			3.6	7	39	Sour	Yes	Insects
BIN B-11, FILLED												
0	Average	3, Garlicky, Tough	14.2	57.3	34.1	0.2	2.9	86	15	Natural	No	None
368	do	Sample, Garlicky, Tough.	14.2	56.0			3.8	21	34	Sour	Yes	Insects
647	do	do	14.4	55.2			5.5	7	49	do	Yes	None
BIN B-12, FILLED												
1	Average	3, Garlicky, Tough	15.4	56.8	33.6	0.4	2.2	91	13	Natural	No	None
10+4	do	do	15.1	56.8			2.4	88	18	do	No	do
10+32	do	do	15.0	56.1			2.4	82	21	do	No	do

See footnotes at end of table.

in quality throughout bin and temperature data of wheat stored in experimental bins 1937, and 1938—Continued

JULY 22, 1937

Variations shown in other portions of bulk at same storage period								Admixtures	Harvest method or source of wheat	First "maximum" temperature period" in center of bulk [4]				Remarks
Moisture		Normal germination		Fat acidity [3]		Total damaged kernels								
Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum			Initial temperature	"Final" temperature	Average temperature	Length of period	
Pct.	*Pct.*	*Pct.*	*Pct.*	*Units*	*Units*	*Pct.*	*Pct.*			°*F.*	°*F.*	°*F.*	*Dy.*	
14.7	----	93	----	------	13	----	2.8	None	Commercial	78	80	78.9	32	
14.8	----	70	54	------	23	----	3.0	do	do	78	80	78.9	32	Fat acidity was interpolated.
15.2	14.4	59	2	40	24	----	3.2	do	do	78	80	78.9	32	

JULY 19, 1937

----	15.0	----	90	15	14	1.9	----	None	Commercial	80	79	76.5	52	
13.8	12.3	72	42	32	24	----	2.6							
----	11.9	71	----	41	27	----	----							
14.3	12.6	63	0	38	32	----	----							

JULY 19, 1937

15.2	14.8	94	78	------	13	----	----	None	Commercial	79	82	80.9	51	
----	12.2	81	9	42	28	2.9	2.6							
----	11.8	72	2	47	33	----	----							

JULY 20, 1937

15.2	----	----	86	20	16	----	----	Lime sulfur.	Commercial	79	81	79.0	50	
15.3	13.2	58	1	44	28	3.2	----							
14.6	13.3	2	0	52	40	4.8	----							

JULY 23, 1937

----	----	----	----	------	------	----	----	None	Commercial	81	80	78.9	46	
----	14.2	84	58	25	20	----	----							
14.7	14.0	8	6	46	42	----	----							

JULY 23, 1937

----	----	----	----	------	------	----	----	None	Commercial	76	79	78.0	46	
14.4	13.8	26	16	40	------	----	----							
----	13.9	24	----	------	38	----	----							

JULY 28, 1937

15.9	----	----	89	20	------	----	----	Bagasse.	Commercial	75	81	76.0	39	Bagasse removed Aug. 7, 1937.
----	----	----	----	------	------	----	----							
----	----	----	----	------	------	----	----							

TABLE 39.—*Condition and quality of wheat, harvest method, admixtures, variations at College Park, in 1936,*

Storage period when sampled (days) [1]	Portion of bulk sampled	Official grade of sample [2]	Moisture content	Test weight per bushel	Weight per 1,000 kernels	Dockage	Total damaged kernels	Normal germination	Fat acidity [3]	Odor	Fumigated	Weevil and other insect infestation
			Pct.	*Lb.*	*Gm.*	*Pct.*	*Pct.*	*Pct.*	*Units*			
BIN B-13, FILLED												
1	Average	3, Garlicky, Tough	15.5	57.2	33.3	0.4	2.2	82	14	Natural	No	None
422	do	Sample, Garlicky, Tough.	15.2	55.0			3.5	7	47	Sour	Yes	do
642	do	do	15.4	54.8			4.5	6	55	do	Yes	do
BIN B-14, FILLED												
1	Average	3, Garlicky, Tough	15.5	57.3	33.4	0.4	2.2	87	23	Natural	No	None
10+4	do	do	15.1	56.9			2.2	85	20	do	No	do
10+32	do	do	15.1	57.0			2.3	68	21	do	No	do
BIN B-15, FILLED												
1	Average	3, Garlicky, Tough	15.5	57.3	33.3	0.4	2.2	85	17	Natural	No	None
365	do	Sample, Garlicky, Tough.	14.8	55.8			3.2	14	41	Musty	Yes	Insects
462	do	do	14.6	55.0			4.8	8	49	Sour	Yes	None
BIN B-16, FILLED												
0	Average	3, Garlicky, Tough	14.2	57.3	34.0	0.2	2.8	86	13	Natural	No	None
392	do	Sample garlicky	13.8	57.0			3.3	10	30	Sour	Yes	do
647	do	do	14.0	56.7			4.5	5	37	do	Yes	do
BIN B-17, FILLED												
0	Average	3, Garlicky, Tough	14.6	56.8	35.0	0.2	2.9	89	21	Natural	No	None
175+14	do	3, Garlicky, Tough	14.3	56.3			2.9	54	25	do	Yes	do
175+217	do	Sample, Garlicky	14.0	55.0			3.6	8	40	Sour	Yes	do
BIN B-19, FILLED												
0	Average	3, Garlicky, Tough	15.4	57.3	33.4	0.4	2.2	91	16	Natural	No	None
42	do	do	15.3	57.4			2.4	71	22	do	No	do
BIN B-20, FILLED												
0	Average	3, Garlicky, Tough	15.5	56.9	33.2	0.4	2.2	74	21	Natural	No	None
310	do	Sample, Garlicky, Tough.	15.5	55.8			2.9	13	37	Musty	No	do
509	do	do	15.3	53.2			4.5	4	51	Sour	No	do
BIN B-21, FILLED												
1	Average	4, Garlicky, Tough, Limed.	15.5	55.0	33.4	0.4	2.2	88	15	Natural	No	None
184	do	do	15.1	54.5			2.5	57	27	do	No	do

See footnotes at end of table.

in quality throughout bin and temperature data of wheat stored in experimental bins 1937, and 1938—Continued

Variations shown in other portions of bulk at same storage period								Admixtures	Harvest method or source of wheat	First "maximum temperature period" in center of bulk [4]				Remarks
Moisture		Normal germination		Fat acidity [3]		Total damaged kernels				Initial temperature	"Final" temperature	Average temperature	Length of period	
Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum							
Pct.	*Pct.*	*Pct.*	*Pct.*	*Units*	*Units*	*Pct.*	*Pct.*			*°F.*	*°F.*	*°F.*	*Dy.*	
JULY 28, 1937														
15.6	14.4	10	5	48	45	----	----	None	Commercial	73	77	74.0	40	
----	14.9	9	----	----	50	----	----							
JULY 28, 1937														
----	----	----	----	----	----	----	----	Brickbats.	Commercial	75	82	79.5	39	Bricks removed Aug. 7, 1937.
----	----	----	----	----	----	----	----							
----	----	----	----	----	----	----	----							
JULY 28, 1937														
----	----	----	----	----	----	----	----	None	Commercial	77	82	80.5	40	
----	13.6	48	13	48	38	----	----							
----	14.2	33	5	54	39	----	----							
JULY 23, 1937														
----	----	----	----	----	----	----	----	None	Commercial	77	82	79.5	45	
14.0	12.6	35	----	32	28	----	----							
14.2	12.5	15	----	37	32	----	----							
JULY 23, 1937														
----	----	----	----	----	----	----	----	None	Commercial	79	82	80.5	45	
15.1	12.6	88	49	29	19	----	----							
----	12.4	37	----	----	28	----	----							
JULY 29, 1937														
----	----	----	----	----	----	----	----	Dried log.	Commercial	75	81	79.5	38	Log was removed Aug. 7, 1937.
----	----	----	----	----	----	----	----							
JULY 29, 1937														
----	----	----	----	----	----	----	----	Formalin.	Commercial	76	82	79.5	39	
----	----	----	----	----	----	----	----	do	do	76	82	79.5	39	Fat acidity was interpolated.
16.4	14.7	6	1	55	49	----	----	do	do	76	82	79.5	39	
JULY 28, 1937														
----	----	----	----	----	----	----	----	Lime-sulfur.	Commercial	74	86	81.0	40	
----	----	----	----	----	----	----	----	do	do	74	86	81.0	40	Emptied for drying machine tests.

TABLE 39.—*Condition and quality of wheat, harvest method, admixtures, variations at College Park, in 1936,*

Storage period when sampled (days)[1]	Portion of bulk sampled	Official grade of sample [2]	Moisture content	Test weight per bushel	Weight per 1,000 kernels	Dockage	Total damaged kernels	Normal germination	Fat acidity [3]	Odor	Fumigated	Weevil and and other insect infestation
			Pct.	*Lb.*	*Gm.*	*Pct.*	*Pct.*	*Pct.*	*Units*			
BIN B-22, FILLED												
1	Average	4, Garlicky, Tough Limed.	15.5	55.2	33.4	0.5	2.3	92	15	Natural	No	None
184	do	do	14.9	54.4			2.5	61	27	do	No	do
BIN B-23, FILLED												
0	Average	3, Garlicky, Tough	15.5	57.2	33.1	0.4	2.2	86	18	Natural	No	None
644	do	3, Garlicky	13.5	56.4			4.0	42	33	do	Yes	Insects
776	do	3, Garlicky Weevily	13.4	56.5			4.2	39	41	do	Yes	Weevils
BIN B-24, FILLED												
0	Average	3, Garlicky, Tough	15.5	57.3	33.4	0.4	2.2	89	16	Natural	No	None
644	do	3, Garlicky	13.4	56.3			4.0	53	35	do	Yes	Insects
853	do	3, Garlicky, Weevily.	13.3	56.4			4.5	43	36	do	Yes	Weevils
BIN B-25, FILLED												
0	Average	3, Garlicky, Tough	15.4	57.3	33.4	0.4	2.2	85	16	Natural	No	None
268	do	Sample, Garlicky, Tough.	15.5	56.0			3.0	68	24	Sour	Yes	do
365	do	do	15.4	56.0			3.8	17	36	do	Yes	do
BIN B-26, FILLED												
1	Average	3, Garlicky, Tough	15.2	57.8	35.5	0.3	1.8	91	14	Natural	No	None
277	do	Sample, Garlicky, Tough.	15.3	57.5			2.8	66	24	Sour	Yes	do
520	do	do	15.3	55.9			4.2	2	42	do	Yes	Insects
BIN B-27, FILLED												
1	Average	Sample, Garlicky	13.7	58.0	35.3	0.3	3.8	65	15	Fireburnt	No	None
162	do	do	13.5	58.0			4.0	32	23	do	No	do
428	do	Sample, Garlicky, Weevily.	13.6	57.6			4.7	6	35	do	No	Weevils
966	do	do	13.4	56.5			9.2	3	42	do	No	do
BIN B-28, FILLED												
1	Average	Sample, Garlicky, Tough.	14.8	58.2	35.5	0.4	2.7	73	18	Fireburnt	No	None
27	do	do	14.8	57.6			2.9	20	30	Sour	No	do
50	do	do	14.8	56.4	36.3	.4	2.9	7	40	do	No	do

See footnotes at end of table.

in quality throughout bin and temperature data of wheat stored in experimental bins 1937, and 1938—Continued

JULY 28, 1937

Variations shown in other portions of bulk at same storage period								Admixtures	Harvest method or source of wheat	First "maximum temperature period" in center of bulk [4]				Remarks
Moisture		Normal germination		Fat acidity [3]		Total damaged kernels				Initial temperature	"Final" temperature	Average temperature	Length of period	
Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum							
Pct.	*Pct.*	*Pct.*	*Pct.*	*Units*	*Units*	*Pct.*	*Pct.*			°*F.*	°*F.*	°*F.*	*Dy.*	
----	----	----	----	------	------	----	----	Lime-sulfur.	Commercial	76	83	80.0	40	
----	----	----	----	------	------	----	----	do	do	76	83	80.0	40	Emptied for drying machine tests.

JULY 29, 1937

----	----	----	----	------	------	----	----	None	Commercial	78	83	78.5	38	
----	12.6	66	----	35	30	----	----							
----	----	----	----	------	------	----	----							

JULY 29, 1937

----	----	----	----	------	------	----	----	None	Commercial	74	82	78.0	38	
13.7	12.2	62	----	------	31	----	----							
----	----	----	----	------	------	----	----							

JULY 29, 1937

15.5	15.3	90	----	19	14	2.3	----	None	Commercial	76	80	79.0	41	
----	15.2	73	60	26	23	----	----	do	do	76	80	79.0	41	Fat acidity was interpolated.
15.6	14.3	49	1	50	26	----	3.5	do	do	76	80	79.0	41	

JULY 20, 1937

----	----	93	----	15	------	----	----	None	Commercial	77	80	78.0	50	
15.5	15.1	----	60	25	------	----	2.6	do	do	77	80	78.0	50	Fat acidity was interpolated.
17.9	14.2	13	0	63	31	----	3.9	do	do	77	80	78.0	50	

JULY 13, 1938

13.8	13.4	83	39	18	15	3.9	3.6	None	Commercial	97	99	98.0	8	Grain passed twice through drying machine at 126° and 129° F. Heat-damaged 0.2 percent.
----	12.9	67	0	29	21	----	----	do	do	97	99	98.0	8	
13.9	13.4	49	0	38	21	----	4.5	do	do	97	99	98.0	8	

JULY 13, 1938

15.0	14.3	80	45	------	14	----	----	None	Commercial	98	111	102.0	25	Grain passed once through drying machine at 124° F. Trace of heat damage.
15.0	13.8	62	0	41	21	----	----	do	do	98	111	102.0	25	
15.2	14.2	60	0	59	22	----	----	do	do	98	111	102.0	25	Heating, wheat removed.

TABLE 39.—*Condition and quality of wheat, harvest method, admixtures, variatiods at College Park, in 1936;*

Storage period when sampled (days)[1]	Portion of bulk sampled	Official grade of sample [2]	Moisture content	Test weight per bushel	Weight per 1,000 kernels	Dockage	Total damaged kernels	Normal germination	Fat acidity [3]	Odor	Fumigated	Weevil and other insect infestation
			Pct.	*Lb.*	*Gm.*	*Pct.*	*Pct.*	*Pct.*	*Units*			
BIN B-29-A, FILLED												
1	Average	Sample, Garlicky	15.8	58.2	36.0	0.4	2.1	78	15	Natural	No	None
12	do	do	15.8	57.8			2.2	68	29	do	No	do
BIN B-29, FILLED												
1	Average	Sample, Garlicky, Tough.	14.4	57.7	35.2	0.3	4.7	31	27	Fireburnt	No	None
416	do	do	14.2	57.0			5.0	1	47	do	No	Insects.
954	do	Sample, Garlicky	14.0	56.4			8.2	0	50	do	No	None
BIN B-30, FILLED												
0	Average	2, Garlicky	14.3	59.1	34.6	0.5	0.8	70	14	Natural	No	None
294	do	do	13.5	59.0			1.0	74	19	do	No	do
612	do	do	13.5	58.5			1.6	57	24	do	Yes	do
967	do	do	13.5	58.3			1.8	60	33	do	Yes	Insects.

[1] Plus sign (+) indicates that grain was moved after previous sampling. Total storage period for any sample is sum of figures, added horizontally.
[2] All wheat of class Soft Red Winter and subclass Red Winter.

in quality throughout bin and temperature data of wheat stored in experimental bins 1937, and 1938—Continued

JULY 13, 1938

Variations shown in other portions of bulk at same storage period								Admixtures	Harvest method or source of wheat	First "maximum" temperature period" in center of bulk [4]				Remarks
Moisture		Normal germination		Fat acidity [3]		Total damaged kernels				Initial temperature	"Final" temperature	Average temperature	Length of period	
Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum							
Pct.	*Pct.*	*Pct.*	*Pct.*	*Units*	*Units*	*Pct.*	*Pct.*			°*F.*	°*F.*	°*F.*	*Dy.*	
----	----	----	----	------	------	----	----	None	Commercial	83	92	87.0	11	Temporary storage before drying.
----	----	----	----	------	------	----	----	do	do	83	92	87.0	11	End of temporary storage.

JULY 25, 1938

14.5	14.3	52	28	30	24	4.9	4.5	None	Commercial	91	90	90.8	21	Grain passed once through drying machine at high temperature—138° F. from drum.
14.4	13.2	10	0	62	27	----	----	do	do	91	90	90.8	21	

JULY 11, 1938

13.4	13.0	83	52	16	11	----	0.7	None	Commercial	85	84	85.0	45	Grain shipped to Baltimore elevator by bay boat.
13.6	12.8	88	76	22	18	----	.9	do	do	85	84	85.0	45	
14.0	11.8	87	12	31	20	----	----	do	do	85	84	85.0	45	
14.6	11.7	87	0	50	25	----	----	do	do	85	84	85.0	45	

[3] Fat acidity, for all samples drawn in 1936, was calculated from the acid value determination and average oil content of soft red winter wheat.

[4] Ordinarily if newly harvested wheat heats in the bin it is during the initial storage period. The temperature data given are for only the period stated in the length of period column.

TABLE 40.—*Description of experimental bins filled at Urbana, in 1936, 1937, and 1938*

BINS FILLED IN 1936

Bin No.	Location of bin	Roof type	Bin surfaces contacting wheat: Floor—material	Bin surfaces contacting wheat: Walls: Material	Bin surfaces contacting wheat: Walls: Number exposed to sun	Bin surfaces contacting wheat: Walls: Resistance to heat transfer [1]	Bulk aeration: Type	Bulk aeration: Air paths through bulk: Average	Bulk aeration: Air paths through bulk: Range	Bulk measurements: Quantity	Bulk measurements: Average depth	Bulk measurements: Half minimum width
								Feet	*Feet*	*Bushels*	*Feet*	*Feet*
U-1	Outdoors	Roll	Metal-lined wood	Metal	(2)	0.7	None	0.0	0.0	298	5.8	3.5
U-2	Outdoors	do	Wood	Wallboard lined cribbing.	0	3.5	do	0	0	294	5.8	3.5
U-3-E	Outdoors	do	do	Wood-lined cribbing	0	3.5	do	0	0	143	5.7	1.7
U-3-W	Outdoors	do	do	do	0	3.5	Ducts	2.0	4.4	138	5.7	1.7
U-4-E	Outdoors	do	do	do	0	3.5	None	0	0	145	5.7	1.7
U-4-W	Outdoors	do	do	do	0	3.5	Forced (wind)	2.0	4.1	138	5.7	1.7
U-5	Outdoors	do	Perforated metal	do	0	3.5	Power	5.9	0	301	5.9	3.5
U-6	Outdoors	do	do	do	0	3.5	Power (hot air)	5.9	0	301	5.9	3.5
U-7	Outdoors	do	Wood	do	0	3.5	Elevator			398	6.2	3.5
U-11	Outdoors	Metal	Metal	Metal	(2)	.7	None	0	0	20	3.0	1.6
U-12	Outdoors	do	do	do	(2)	.7	do	0	0	20	3.0	1.6
U-13	Outdoors	do	do	do	(2)	.7	do	0	0	20	3.0	1.6
U-14	Outdoors	do	do	do	(2)	.7	do	0	0	15	3.0	1.6
U-15	Outdoors	do	do	do	(2)	.7	do	0	0	20	3.0	1.6
U-21	Outdoors	Wallboard	Insulated metal	Insulated metal	(2)	10.69	do	0	0	20	3.0	1.6
U-22	Outdoors	do	do	do	(2)	10.69	do	0	0	20	3.0	1.6
U-23	Outdoors	do	do	do	(2)	10.69	do	0	0	20	3.0	1.6
U-24	Outdoors	do	do	do	(2)	10.69	do	0	0	15	3.0	1.6
U-25	Outdoors	do	do	do	(2)	10.69	do	0	0	20	3.0	1.6

BINS FILLED IN 1937

Bin No.	Location of bin	Roof type	Bin surfaces contacting wheat: Floor—material	Bin surfaces contacting wheat: Walls: Material	Bin surfaces contacting wheat: Walls: Number exposed to sun	Bin surfaces contacting wheat: Walls: Resistance to heat transfer [1]	Bulk aeration: Type	Bulk aeration: Air paths through bulk: Average	Bulk aeration: Air paths through bulk: Range	Bulk measurements: Quantity	Bulk measurements: Average depth	Bulk measurements: Half minimum width
U-1	Outdoors	Roll	Wood	Wood-lined cribbing	0	3.5	None	0	0	277	5.5	3.5
U-2	Outdoors	do	do	do	0	3.5	do	0	0	239	4.8	3.5
U-3	Outdoors	do	do	do	0	3.5	Forced (wind)	2.0	2.3	284	5.8	3.5
U-5	Outdoors	do	Perforated metal	do	0	3.5	Power (fan)	1.7	.6	284	5.8	3.5
U-6	Outdoors	do	do	do	0	3.5	do	1.8	.5	276	5.6	3.5
U-7	Outdoors	do	Wood	do	0	3.5	Elevator			250	5.0	3.5
U-8	Outdoors	do	do	do	0	3.5	Forced (wind)	1.0	1.4	305	6.2	3.5

U-11	Outdoors	Metal	Metal	Metal	(2)	.7	None	0	0	20	2.8	1.6
U-12		do	do	do	(2)	.7	do	0	0	20	2.8	1.6
U-13		do	do	do	(2)	.7	do	0	0	20	2.8	1.6
U-14	3-sided shed	do	do	do	(3)	.7	do	0	0	20	2.8	1.6
U-15		do	do	do	(3)	.7	do	0	0	20	2.8	1.6
U-16		do	do	do	(3)	.7	do	0	0	20	2.8	1.6
U-17	Outdoors	do	do	do	(2)	.7	do	0	0	20	2.8	1.6
U-18		do	do	do	(2)	.7	do	0	0	20	2.8	1.6
U-21		do	do	do	(2)	.7	do	0	0	20	3.0	1.9
U-22		do	do	do	(2)	.7	do	0	0	28	3.0	1.9
U-23		Wallboard	Insulated metal	Insulated metal	(2)	10.69	do	0	0	20	2.8	1.6
U-24		do	do	do	(2)	10.69	do	0	0	20	2.8	1.6
U-25		do	do	do	(2)	10.69	do	0	0	20	2.8	1.6
U-26	Underground	Metal	Metal	Metal	0	.45	Restricted			6	3.0	1.0
U-27		do	do	do	0	.45	do			6	3.0	1.0
U-28		do	do	do	0	.45	Restricted (sealed)			6	3.0	1.0

BINS FILLED IN 1938

U-2	Outdoors	Roll	Wood	Screen and wood-lined cribbing.	0	3.5	Forced (wind)	3.2	5.1	294	5.9	3.2
U-3		do	do	Screen-lined cribbing	0		Wall surface	3.2	6.6	286	5.8	1.6
U-4		do	do	Wood-lined cribbing	0	3.5	None	0	0	296	5.9	3.5
U-5		do	Perforated metal	do	0	3.5	Power	4.5	3.5	304	6.2	3.5
U-29		do	Wood	Wood	(2)	1.68	Ducts	1.5	2.9	30	3.5	1.6
U-30		Metal	Metal	Metal	(2)	.7	None	0	0	20	2.8	1.6
U-31		do	do	do	(2)	.7	do	0	0	20	2.8	1.6
U-32		do	do	do	(2)	.7	do	0	0	20	2.8	1.6
U-33		do	do	do	(2)	.7	do	0	0	20	2.8	1.6
U-34		do	Metal (venthole)	do	(2)	.7	None (floor-vent)	3.0	.5	20	2.8	1.6
U-35		do	do	do	(2)	.7	do	2.0	.5	20	2.8	1.6
U-36		do	Metal	do	(2)	.7	None	0	0	20	2.8	1.6
U-37		do	do	do	(2)	.7	do	0	0	20	2.8	1.6
U-38		do	do	do	(2)	.7	do	0	0	20	2.8	1.6
U-39		do	do	do	(2)	.7	do	0	0	20	2.8	1.6
U-40		do	do	do	(2)	.7	do	0	0	20	2.8	1.6
U-41		do	do	do	(2)	.7	do	0	0	20	2.8	1.6

[1] Resistance or degrees Fahrenheit difference in temperature on opposite surface of wall which will cause 1 B. t. u. of heat to pass through an area of 1 square foot in 1 hour.

[2] All walls supporting wheat exposed to sun.

[3] Part of one wall exposed to sun.

TABLE 41.—*Condition and quality of wheat, harvest method, admixtures, variations at Urbana in 1936,*

Storage period when sampled (days) [1]	Portion of bulk sampled	Official grade of sample [2]	Moisture content	Test weight per bushel	Weight per 1,000 kernels	Dockage	Total damaged kernels	Normal germination	Fat acidity [3]	Odor	Fumigated	Weevil and other insect infestation
			Pct.	*Lb.*	*Gm.*	*Pct.*	*Pct.*	*Pct.*	*Units*			
BIN U-1, FILLED												
1	Average	Sample, Garlicky	15.7	61.0	32.2		2.7	82	17	Natural	No	None
19+9+6	do	4, Light garlicky, Tough.	14.2	60.0			9.5	18		do	No	do
19+9+46	do	Sample, Light garlicky.	13.8	59.7			30.0	12		Musty	No	Weevils.
BIN U-2, FILLED												
1	Average	Sample	15.7	61.0	32.5		2.4	83	17	Natural	No	None
20+49+1	do	Sample, Garlicky	13.8	60.0			16.0	18		do	No	Insects.
20+49+22	do	do	13.6	60.0			17.0	17		Musty	No	do
BIN U-3-E, FILLED												
1	Average	Sample, Light garlicky.	15.7	61.0	32.5	0.6	2.4	84	16	Natural	No	None
18+13	do	4, Light garlicky, Tough.	14.5	59.6			9.0	19		do	No	do
18+13+25	do	Sample, Light garlicky tough.	14.5	59.6		.4	20.0	7		Musty	No	do
18+13+25+17	do	Sample, Light garlicky.	13.9	59.7			30.0	8		do	No	Insects.
BIN U-3-W, FILLED												
1	Average	Sample, Light garlicky.	15.7	61.0	32.5	0.6	2.4	84	16	Natural	No	None
89	do	Sample, Light garlicky, Weevily, Tough.	14.1	59.8		.5	18.0	17	48	do	No	Weevils
BIN U-4-E, FILLED												
0	Average	1, Light garlicky, Tough.	14.2	61.1	32.3	0.5	1.2	84	17	Natural	No	None
396	do	3, Tough	14.6	59.8		.4	7.0	45	37	Slight weevily.	No	(?)
446	do	Sample, Weevily, Tough.	14.2	59.0	33.6	.5	12.2	19	34	Musty	No	Weevils
BIN U-4-W, FILLED												
0	Average	1, Light garlicky, Tough.	14.2	61.6	32.3	0.5	1.2	84	17	Natural	No	None
396	do	3	13.7	59.7		.5	4.5	70	25	Slight weevily.	No	(?)
446	do	3, Weevily	13.6	59.5	33.4	.5	4.6	60	27	do	No	Weevils

See footnotes at end of table.

in quality throughout bin and temperature data of wheat stored in experimental bins 1937, and 1938

Variations shown in other portions of bulk at same storage period								Admixtures	Harvest method or source of wheat	First maximum temperature period in center of bulk [4]				Remarks
Moisture		Normal germination		Fat acidity [3]		Total damaged kernels								
Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum			Initial temperature	Final temperature	Average temperature	Length of period	
Pct.	*Pct.*	*Pct.*	*Pct.*	*Units*	*Units*	*Pct.*	*Pct.*			°*F.*	°*F.*	°*F.*	*Dy.*	
JULY 2, 1936														
----	----	----	----	----	----	----	----	None	Combine and shipped.	88	121	97.5	19	
JULY 2, 1936														
----	----	----	----	----	----	----	----	None	Combine and shipped.	86	120	98.0	20	
JULY 2, 1936														
----	----	----	----	----	----	----	----	None	Combine and shipped.	86	120	98.5	18	
JULY 2, 1936														
----	----	----	----	----	----	----	----	None	Combine and shipped.	83	100	87.5	55	
JULY 4, 1936														
----	----	----	----	----	----	----	----	None	Combine and shipped.	91	91	90.5	21	
----	----	----	----	----	----	----	----	do	do	91	91	90.5	21	No insects in sample. Damage (immature, mold, sick wheat, weevil bored).
16.1	----	37	2	45	29	65.0	5.2	do	do	91	91	90.5	21	Damage (immature, mold, sick wheat, weevil bored).
JULY 4, 1936														
----	----	----	----	----	----	----	----	None	Combine and shipped.	90	85	80.0	56	
----	----	----	----	----	----	----	----	do	do	90	85	80.0	56	No insects in sample.
----	----	----	----	----	----	----	----	do	do	90	85	80.0	56	Damage (immature, weevil bored, sick).

TABLE 41.—*Condition and quality of wheat, harvest method, admixtures, variations at Urbana in 1936, 1937,*

Storage period when sampled (days)[1]	Portion of bulk sampled	Official grade of sample [2]	Moisture content	Test weight per bushel	Weight per 1,000 kernels	Dockage	Total damaged kernels	Normal germination	Fat acidity [3]	Odor	Fumigated	Weevil and other insect infestation
			Pct.	*Lb.*	*Gm.*	*Pct.*	*Pct.*	*Pct.*	*Units*			
BIN U-5, FILLED												
0	Average	1, Tough	14.2	61.4	32.9	0.3	1.0	86	------	Natural	No	None
87	do	1	13.5	60.9	----	.4	1.5	----	------	do	No	Weevils
346	do	3, Tough	14.7	60.0	----	.3	6.0	26	------	do	Yes	None
BIN U-6, FILLED												
0	Average	1, Tough	14.3	61.4	33.0	0.3	1.5	86	------	Natural	No	None
87	do	1	13.9	60.4	----	.5	1.7	----	------	do	No	Weevils
346	do	5, Tough	14.7	59.8	----	.5	12.8	27	------	do	Yes	None
BIN U-7, FILLED												
0	Average	1, Tough	14.1	61.2	30.5	0.3	1.7	89	------	Natural	No	None
87	do	do	14.2	60.3	----	.5	2.0	65	------	do	No	Weevils
BIN U-11, FILLED												
0	Average	2	13.3	59.4	32.5	0.8	2.7	77	------	Natural	No	None
88	do	2, Weevily	12.7	59.4	----	.5	2.5	----	------	do	No	Weevils
BIN U-12, FILLED												
0	Average	2, Garlicky, Tough	15.1	59.8	32.4	0.7	3.0	79	------	Natural	No	None
82	do	Sample, Garlicky, Tough.	14.4	59.2	----	----	33.5	26	------	Musty	No	Insects
BIN U-13, FILLED												
0	Average	Sample	15.6	60.0	32.4	0.5	2.3	92	------	Natural	No	None
82	do	Sample, Tough	14.6	58.8	----	.3	51.0	22	------	Musty	No	Weevils
BIN U-14, FILLED												
0	Average	Sample, Garlicky	16.7	59.6	32.3	0.3	3.7	80	------	Natural	No	None
82	do	Sample, Garlicky, Tough.	14.3	56.7	----	----	70.0	37	------	Musty	No	Weevils
BIN U-15, FILLED												
0	Average	Sample, Light garlicky.	17.5	59.4	32.8	0.2	2.3	81	------	Natural	No	None
82	do	Sample, Light garlicky, Tough.	15.1	56.2	----	----	65.0	19	------	Musty	No	Insects

See footnotes at end of table.

in quality throughout bin and temperature data of wheat stored in experimental bins and 1938—Continued

Variations shown in other portions of bulk at same storage period								Admixtures	Harvest method or source of wheat	First "maximum" temperature period" in center of bulk [4]				Length of period	Remarks
Moisture		Normal germination		Fat acidity [3]		Total damaged kernels					Initial temperature	"Final" temperature	Average temperature		
Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum								
Pct.	*Pct.*	*Pct.*	*Pct.*	*Units*	*Units*	*Pct.*	*Pct.*			°*F.*	°*F.*	°*F.*	*Dy.*		
JULY 4, 1936															
----	----	----	----	----	----	----	----	None	Combine and shipped.	91	84	82.5	55		
JULY 4, 1936															
----	----	----	----	----	----	----	----	None	Combine and shipped.	91	102	95.5	21		
JULY 4, 1936															
----	----	----	----	----	----	----	----	None	Combine and shipped.	90	93	90.5	10		
JULY 4, 1936															
----	----	----	----	----	----	----	----	None	Combine and shipped.	94	100	96.8	12		
JULY 3, 1936															
----	----	----	----	----	----	----	----	None	Combine and shipped.	91	107	98.0	13		
----	----	----	----	----	----	----	----	do	do	91	107	98.0	13	Damage (immature, moldy, sick).	
JULY 3, 1936															
----	----	----	----	----	----	----	----	None	Combine and shipped.	85	114	100.0	13		
----	----	----	----	----	----	----	----	do	do	85	114	100.0	13	Damage (immature, moldy, sick).	
JULY 3, 1936															
----	----	----	----	----	----	----	----	Peat	Combine and shipped.	87	123	109.0	13		
----	----	----	----	----	----	----	----	do	do	87	123	109.0	13	Damage (immature, moldy, sick, trace of heat).	
JULY 3, 1936															
----	----	----	----	----	----	----	----	None	Combine and shipped.	84	124	111.0	13		
----	----	----	----	----	----	----	----	do	do	84	124	111.0	13	Damage (immature, moldy, sick, trace of heat).	

TABLE 41.—*Condition and quality of wheat, harvest method, admixtures, variations at Urbana in 1936, 1937,*

Storage period when sampled (days)[1]	Portion of bulk sampled	Official grade of sample [2]	Moisture content	Test weight per bushel	Weight per 1,000 kernels	Dockage	Total damaged kernels	Normal germination	Fat acidity [3]	Odor	Fumigated	Weevil and other insect infestation
			Pct.	*Lb.*	*Gm.*	*Pct.*	*Pct.*	*Pct.*	*Units*			
BIN U-21, FILLED												
0	Average	2	13.0	59.0	32.3	0.9	3.2	81		Natural	No	None
88	do	2, Weevily	12.8	59.7		.6	2.8			do	No	Weevils
BIN U-22, FILLED												
0	Average	2, Tough	15.2	59.8	33.0	0.7	3.3	84		Natural	No	None
82	do	Sample, Tough	14.2	58.7		.7	34.0	23		Musty	No	Weevils
BIN U-23, FILLED												
0	Average	Sample	15.7	61.0	32.8	0.3	2.0	82		Natural	No	None
82	do	Sample, Tough	14.4	58.6			45.0	29		Musty	No	Weevils
BIN U-24, FILLED												
0	Average	Sample, Garlicky	16.8	60.0	32.2	0.6	2.9	77		Natural	No	None
82	do	Sample, Garlicky, Tough	14.8	57.0			60.0	28		Musty	No	Weevils
BIN U-25, FILLED												
0	Average	Sample, Light garlicky.	17.6	59.4	32.0	0.1	2.0	83		Natural	No	None
82	do	do	15.8	56.3			75.0	11		Musty	No	Weevils
BIN U-1, FILLED												
1	Average	3, Light garlicky, Tough.	14.2	57.7	31.8	0.3	0.5	82	16	Natural	No	None
69	do	3, Light garlicky, Tough, Limed.	14.2	57.0	31.7	.4	.7	72	19	do	No	Weevils
BIN U-2, FILLED												
1	Average	3, Light garlicky, Tough.	14.2	57.2	31.5	0.2	0.4	80	15	Natural	No	None
69	do	do	14.2	57.1	31.1	.4	.7	80	18	do	No	Insects

See footnotes at end of table.

in quality throughout bin and temperature data of wheat stored in experimental bins and 1938—Continued

Variations shown in other portions of bulk at same storage period								Admixtures	Harvest method or source of wheat	First "maximum" temperature period" in center of bulk [4]				Remarks
Moisture		Normal germination		Fat acidity [3]		Total damaged kernels				Initial temperature	"Final" temperature	Average temperature	Length of period	
Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum							
Pct.	*Pct.*	*Pct.*	*Pct.*	*Units*	*Units*	*Pct.*	*Pct.*			°*F.*	°*F.*	°*F.*	*Dy.*	
JULY 4, 1936														
----	----	----	----	----	----	----	----	None	Combine and shipped.	94	95	93.5	13	
JULY 3, 1936														
----	----	----	----	----	----	----	----	None	Combine and shipped.	91	103	95.5	15	
----	----	----	----	----	----	----	----	do	do	91	103	95.5	15	Damage (immature, moldy, sick).
JULY 3, 1936														
----	----	----	----	----	----	----	----	None	Combine and shipped.	85	110	96.5	14	
----	----	----	----	----	----	----	----	do	do	85	110	96.5	14	Damage (immature, moldy, sick).
JULY 3, 1936														
----	----	----	----	----	----	----	----	Peat	Combine and shipped.	88	123	105.8	13	
----	----	----	----	----	----	----	----	do	do	88	123	105.8	13	Damage (immature, moldy, sick, trace of heat).
JULY 3, 1936														
----	----	----	----	----	----	----	----	None	Combine and shipped.	82	124	106.0	13	
----	----	----	----	----	----	----	----	do	do	82	124	106.0	13	Damage (immature, moldy, sick, trace of heat).
JULY 16, 1937														
14.3	14.1	83	79	----	13	----	0.4	Lime sulfur.	Combine	85	88	83.0	69	Stored in bin U-5 from July 8 to July 16, 1937.
----	----	79	----	----	19	----	.6	do	do	85	88	83.0	69	
JULY 16, 1937														
----	14.1	83	----	22	----	0.5	0.3	Pyrethrum.	Combine	84	85	84.6	8	Stored in bin U-6 from July 8 to July 16, 1937.
14.4	14.1	81	75	----	17	----	.6	do	do	84	85	84.6	8	

TABLE 41.—*Condition and quality of wheat, harvest method, admixtures, variations at Urbana in 1936, 1937,*

Storage period when sampled (days)[1]	Portion of bulk sampled	Official grade of sample [2]	Moisture content	Test weight per bushel	Weight per 1,000 kernels	Dockage	Total damaged kernels	Normal germination	Fat acidity [3]	Odor	Fumigated	Weevil and other insect infestation
			Pct.	*Lb.*	*Gm.*	*Pct.*	*Pct.*	*Pct.*	*Units*			
BIN U-3, FILLED												
1	Average	Sample, Garlicky	17.2	56.0	32.0	0.5	0.6	66	19	Natural	No	None
24	do	do	16.6	55.0	32.0	.5	.9	36	42	Musty	No	do
BIN U-5, FILLED												
0	Average	Sample, Light garlicky.	16.3	54.5	----	0.6	3.0	61	21	Natural	No	None
69	do	4, Light garlicky, Limed.	13.7	55.3	31.5	.4	4.9	51	32	Limed	No	Weevils
BIN U-6, FILLED												
1	Average	Sample, Light garlicky.	15.9	56.3	32.8	0.5	0.4	70	21	Natural	No	None
69	do	3, Light garlicky	12.5	56.6	32.3	.5	4.5	51	32	do	No	Weevils
BIN U-7, FILLED												
0	Average	2, Light garlicky, Tough	14.7	58.2	30.1	0.4	0.4	83	9	Natural	No	None
77	do	do	14.4	57.7	30.6	.4	1.0	71	21	do	No	Insects
BIN U-8, FILLED												
1	Average	Sample, Garlicky	17.0	56.0	32.3	0.5	0.7	70	21	Natural	No	None
39	do	do	16.3	55.7	32.2	.4	2.6	37	37	Musty	No	Insects
BIN U-11, FILLED												
1	Average	2	12.8	59.6	31.8	0.2	0.4	85	16	Natural	No	None
909	do	2	12.7	59.0	----	.4	.7	82	28	do	Yes	do
1,367	do	2	12.9	58.2	----	.4	1.0	----	----	do	Yes	do
BIN U-12, FILLED												
1	Average	2	13.8	58.5	32.1	0.3	0.7	81	16	Natural	No	None
909	do	2	13.0	58.0	----	.4	.9	78	30	do	Yes	Insects
1,367	do	3	13.7	57.7	----	.4	1.5	----	----	do	Yes	do
BIN U-13, FILLED												
1	Average	3, Light garlicky, Tough.	14.7	57.4	30.0	0.3	0.9	68	15	Natural	No	None
909	do	3	13.7	56.5	----	.4	1.0	32	33	do	Yes	Insects
1,367	do	3	13.8	56.3	----	.4	7.0	----	----	do	Yes	do

See footnotes at end of table.

in quality throughout bin and temperature data of wheat stored in experimental bins 1937, and 1938—Continued

Variations shown in other portions of bulk at same storage period								Admixtures	Harvest method or source of wheat	First "maximum" temperature period" in center of bulk [4]				Remarks
Moisture		Normal germination		Fat acidity [3]		Total damaged kernels				Initial temperature	"Final" temperature	Average temperature	Length of peir	
Maximum	Minimum	Maximum	Minimum	Maximum	Maximum	Minimum	Minimum							
Pct.	*Pct.*	*Pct.*	*Pct.*	*Units*	*Units*	*Pct.*	*Pct.*			°*F.*	°*F.*	°*F.*	*Dy.*	
JULY 12, 1937														
----	16.9	67	65	20	18	-	0.4	None	Combine and shipped.	88	95	90.0	13	
16.9	16.1	46	21	53	42	----	.7							
JULY 16, 1937														
16.4	----	66	60	21	18	3.4	----	Lime sulfur.	Combine	89	90	83.0	27	Stored in bin U-1 from July 8 to July 16, 1937.
14.0	13.3	60	43	32	29	5.3	4.0	do	do	89	90	83.0	27	
JULY 16, 1937														
16.1	----	----	64	25	----	0.7	----	Pyrethrum.	Combine	89	90	83.5	27	Stored in bin U-2, from July 8 to July 16, 1937.
13.4	11.1	----	40	34	30	4.9	4.2	do	do	89	90	83.5	27	
JULY 8, 1937														
----	14.5	----	79	18	15	0.5	----	None	Combine	89	80	78.4	58	
14.6	14.2	81	64	22	18	----	0.8							
JULY 11, 1937														
----	16.9	71	65	----	19	0.8	----	None	Commercial	89	83	81.2	39	
16.5	15.8	46	31	42	35	3.2	2.4							
JULY 7, 1937														
----	----	----	----	----	----	----	----	None	Combine	87	86	83.0	45	
13.2	12.1	83	81	29	27	----	----							
----	----	----	----	----	----	----	----							
JULY 7, 1937														
----	----	----	----	----	----	----	----	None	Combine	84	86	82.5	45	
13.5	12.2	81	66	31	28	----	----							
----	----	----	----	----	----	----	----							
JULY 7, 1937														
----	----	----	----	----	----	----	----	None	Combine	88	85	82.5	45	
14.1	12.8	56	28	35	31	----	----							
----	----	----	----	----	----	----	----							

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TABLE 41.—*Condition and quality of wheat, harvest method, admixtures, variations at Urbana in 1936, 1937,*

Storage period when sampled (days) [1]	Portion of bulk sampled	Official grade of sample [2]	Moisture content	Test weight per bushel	Weight per 1,000 kernels	Dockage	Total damaged kernels	Normal germination	Fat acidity [3]	Odor	Fumigated	Weevil and other insect infestation
			Pct.	*Lb.*	*Gm.*	*Pct.*	*Pct.*	*Pct.*	*Units*			
BIN U-14, FILLED												
1	Average	2	13.1	59.8	31.5	0.3	0.3	84	18	Natural	No	None
912	do	2	13.4	58.5	-----	.5	.8	69	27	do	Yes	Weevils
1,370	do	2, Tough	14.4	58.0	-----	.4	1.0	----	------	do	Yes	do
BIN U-15, FILLED												
1	Average	2, Light garlicky, Tough.	14.1	58.5	30.7	0.3	0.4	84	15	Natural	No	None
912	do	2, Light garlicky	14.0	58.0	-----	.4	.9	78	27	do	Yes	Insects
1,370	do	3, Tough, Light garlicky.	14.7	57.0	-----	.5	1.0	----	------	do	Yes	None
BIN U-16, FILLED												
1	Average	3, Light garlicky, Tough.	14.6	57.5	29.0	0.3	0.4	80	15	Natural	No	None
913	do	3, Tough	14.7	56.1	-----	.4	1.0	52	27	do	Yes	Weevils
1,276	do	Sample, Tough	14.9	55.5	-----	.5	4.8	20	32	COFO [5]	Yes	do
BIN U-17, FILLED												
1	Average	2, Light garlicky, Tough.	14.1	58.3	32.5	0.5	0.4	83	17	Natural	No	None
30+40	do	2, Light garlicky	13.4	58.2	32.0	.4	.5	84	19	do	No	Weevils
BIN U-17, FILLED												
99	Average	3, Tough, Limed	14.6	57.0	-----	0.4	0.8	79	18	Natural	Yes	None
657	do	Sample, Tough, Limed.	14.3	55.5	-----	.4	4.5	23	39	Musty	Yes	Insects
BIN U-18, FILLED												
1	Average	2, Light garlicky, Tough.	14.1	58.3	32.5	0.5	0.4	83	17	Natural	No	None
	do	3, Limed	13.6	56.6	-----	.5	1.0	34	30	Fumigant	Yes	do
30+871	do	do	13.8	56.8	-----	.4	4.7	----	------	Limed	Yes	do
30+1,327												

See footnotes at end of table.

in quality throughout bin and temperature data of wheat stored in experimental bins and 1938—Continued

JULY 7, 1937

Variations shown in other portions of bulk at same storage period								Admixtures	Harvest method or source of wheat	First "maximum" temperature period" in center of bulk [4]				Remarks
Moisture		Normal germination		Fat acidity [3]		Total damaged kernels				Initial temperature	"Final" temperature	Average temperature	Length of period	
Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum							
Pct.	*Pct.*	*Pct.*	*Pct.*	*Units*	*Units*	*Pct.*	*Pct.*			°*F.*	°*F.*	°*F.*	*Dy.*	
13.9		74	67		26			None	Combine	88	78	75.8	37	

JULY 7, 1937

14.2	13.6		69	28				None	Combine	84	78	76.1	46	

JULY 7, 1937

14.8 15.0	14.5 14.2	56 34	36 11	28 32	26 30			None	Combine	88	78	77.0	45	

JULY 15, 1937

								Straw	Combine	85	88	81.0	30	Wheat from bin U-7 thoroughly mixed. 13.4 bushels plus 20 pounds dry wheat straw.
								do	do	85	88	81.0	30	Straw removed Aug. 14, 1937.

OCT. 13, 1937

wet	12.7	38		42	31			None	Combine	(?)	85	(?)	(?)	Wheat from bin U-1.

JULY 15, 1937

								Straw + lime sulfur	Combine	87	83	80.6	36	Wheat from bin U-7. 14.6 bushels plus 20 pounds straw plus 1½ lbs. lime sulfur.
14.3	13.2	41	26	32	28				do	87	83	80.6	36	
									do	87	83	80.6	36	Straw removed Aug. 14, 1937.

TABLE 41.—*Condition and quality of wheat, harvest method, admixtures, variations at Urbana in 1936, 1937,*

Storage period when sampled (days)[1]	Portion of bulk sampled	Official grade of sample [2]	Moisture content	Test weight per bushel	Weight per 1,000 kernels	Dockage	Total damaged kernels	Normal germination	Fat acidity [3]	Odor	Fumigated	Weevil and other insect infestation
			Pct.	*Lb.*	*Gm.*	*Pct.*	*Pct.*	*Pct.*	*Units*			
BIN U-21, FILLED												
1	Average	2, Light garlicky, Tough.	14.1	58.3	32.5	0.5	0.4	83	17	Natural	No	None
30+875	do	3	13.6	57.4		.5	1.0	55	28	do	Yes	do
30+1,327	do	3	13.9	57.0		.4	1.0			do	Yes	do
BIN U-22, FILLED												
1	Average	2, Light garlicky, Tough.	14.1	58.3	32.5	0.5	0.4	83	17	Natural	No	None
30+875	do	5, Limed	13.6	53.7		.5	1.0	75	25	Limed	Yes	do
30+1,332	do	do	13.8	53.8		.3	1.0			do	Yes	Insects
BIN U-23, FILLED												
1	Average	3, Light garlicky	13.5	59.4	30.3	0.2	0.4	89	15	Natural	No	None
78	do	do	12.9	59.0	31.5	.3	.5	77	19	do	No	Weevils
BIN U-23, FILLED												
99	Average	3, Light garlicky, Tough.	14.7	57.4		0.4	0.8	83	18	Natural	No	None
811	do	3	13.9	57.0		.5	1.0	59	30	do	No	Weevils
1,267	do	3, Tough, Weevily	14.5	57.0		.4	1.2			do	No	do
BIN U-24, FILLED												
1	Average	2, Light garlicky	13.8	58.7	31.3	0.2	0.3	86	15	Natural	No	None
78	do	do	13.1	58.4		.3	.5	87	19	do	No	Weevils
BIN U-24, FILLED												
99	Average	3, Light garlicky	13.6	56.3		0.5	4.2	61	28	Natural	No	None
811	do	4, Light garlicky	13.3	56.1		.4	10.0	52	42	Storage	No	Insects
1,269	do	5, Light garlicky	13.8	56.5		.5	14.0			Natural	No	None
BIN U-25, FILLED												
1	Average	2, Garlicky, Tough	14.3	58.7		0.3	0.6	80	15	Natural	No	None
78	do	2, Garlicky	13.7	58.4		.4	.5	82	19	do	No	Weevils

See footnotes at end of table.

in quality throughout bin and temperature data of wheat stored in experimental bins and 1938—Continued

Variations shown in other portions of bulk at same storage period								Admixtures	Harvest method or source of wheat	First "maximum temperature period" in center of bulk [4]				Remarks
Moisture		Normal germination		Fat acidity [3]		Total damaged kernels				Initial temperature	"Final" temperature	Average temperature	Length of period	
Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum							
Pct.	*Pct.*	*Pct.*	*Pct.*	*Units*	*Units*	*Pct.*	*Pct.*			°*F.*	°*F.*	°*F.*	*Dy.*	
----	----	----	----	----	----	----	----	Straw	Combine	85	90	80.7	31	Wheat from bin U-7. 20 bushels plus 40 pounds straw in layers.
14.0	12.8	56	52	31	----	----	----	do	do	85	90	80.7	31	Straw removed Aug. 14, 1937.
----	----	----	----	----	----	----	----	do	do	85	90	80.7	31	
JULY 15, 1937														
----	----	----	----	----	----	----	----	Unslaked lime	Combine	95	92	85.8	30 +1	Wheat from bin U-7. 28.2 bushels plus 50 pounds unslaked lime.
13.8	13.2	78	68	26	25	----	----	do	do	95	92	85.8	30	
----	----	----	----	----	----	----	----	do	do	95	92	85.8	30 +1	Bulk of lime removed Aug, 14, 1937.
JULY 7, 1937														
----	----	----	----	----	----	----	----	None	Combine	86	83	80.5	48	
OCT. 13, 1937														
14.6	13.3	60	53	31	29	----	----	Pyrethrum	Combine	(?)	82	(?)	(?)	Wheat from bin U-2.
JULY 7, 1937														
----	----	----	----	----	----	----	----	None	Combine	85	83	80.4	47	
OCT. 13, 1937														
13.6	12.9	----	48	44	----	----	----	Pyrethrum	Combine	(?)	81	(?)	(?)	Wheat from bin U-6 treated with pyrethrum.
JULY 7, 1937														
----	----	----	----	----	----	----	----	None	Combine	84	83	80.0	47	

TABLE 41.—*Condition and quality of wheat, harvest method, admixtures, variations at Urbana in 1936,*

Storage period when sampled (days)[1]	Portion of bulk sampled	Official grade of sample [2]	Moisture content	Test weight per bushel	Weight per 1,000 kernels	Dockage	Total damaged kernels	Normal germination	Fat acidity [3]	Odor	Fumigated	Weevil and other insect infestation
			Pct.	*Lb.*	*Gm.*	*Pct.*	*Pct.*	*Pct.*	*Units*			
BIN U-25, FILLED												
99	Average	4, Light garlicky, Tough.	15.3	55.1		0.4	4.7	56	33	Natural	No	None
225	do	Sample, Light garlicky, Tough, Limed.	14.8	55.0			7.7	43	40	Musty	Yes	do
809	do	do	14.6	54.7		.5	16.0	6	51	do	Yes	Weevils
BIN U-26, FILLED												
1	Average	1	12.7	60.0		0.2	0.3	86	15	Natural	No	None
909	do	2	13.2	59.5		.4	.9	0	27	Fumigant	Yes	do
1,267	do	Sample	16.0	57.0			7.2	0	39	Sour	Yes	Weevils
BIN U-27, FILLED												
1	Average	3, Light garlicky, Tough.	14.5	57.7		0.3	0.4	79	11	Natural	No	None
902	do	do	14.4	57.2		.4	1.0	0	34	Fumigant	Yes	do
1,363	do	3, Tough	15.0	56.7		.5	5.5			do	Yes	do
BIN U-28, FILLED												
1	Average	3, Light garlicky, Tough.	14.5	57.7		0.3	0.4	79	14	Natural	No	None
915	do	3, Tough	15.4	56.8		.5	.8	78	30	do	Yes	do
1,276	do	do	15.2	56.7		.4	1.5			do	Yes	do
BIN U-2, FILLED												
2	Average	2, Light garlicky, Tough	14.7	59.6	33.5	0.3	(6)	85	16	Natural	No	None
58	do	do	14.6	59.6		.4	(6)	93	23	Fumigant	Yes	do
185	do	do	14.6	59.3		.4	0.7	81	22	do	Yes	do
550	do	3, Light garlicky, Tough	14.2	58.2		.5	4.5	68	25	Natural	Yes	Insects
729	do	Sample, Tough, Light garlicky, Weevily.	14.6	58.0		.4	12.0	25	33	Musty	Yes	do

See footnotes at end of table.

in quality throughout bin and temperature data of wheat stored in experimental bins and 1938—Continued

OCT. 13, 1937

Variations shown in other portions of bulk at same storage period								Admixtures	Harvest method or source of wheat	First "maximum temperature period" in center of bulk [4]				Remarks
Moisture		Normal germination		Fat acidity [3]		Total damaged kernels				Initial temperature	"Final" temperature	Average temperature	Length of period	
Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum							
Pct.	*Pct.*	*Pct.*	*Pct.*	*Units*	*Units*	*Pct.*	*Pct.*			°*F.*	°*F.*	°*F.*	*Dy.*	
----	----	----	----	----	----	----	----	Lime-sulfur	Combine	(?)	82	(?)	(?)	Wheat from bin U-5 treated with lime sulfur.
----	----	----	----	----	----	----	----	do	do	(?)	82	(?)	(?)	Fat acidity was interpolated.
14.6	14.1	11	----	51.0	45.4	----	----	do	do	(?)	82	(?)	(?)	
JULY 7, 1937														
----	----	----	----	----	----	----	----	None	Combine	85	73	69.2	46	
----	----	----	----	----	----	----	----							
----	----	----	----	----	----	----	----							
JULY 14, 1937														
----	----	----	----	----	----	----	----	None	Combine	86	71	69.0	39	
----	----	----	----	----	----	----	----	do	do	86	71	69.0	39	
----	----	----	----	----	----	----	----	do	do	86	71	69.0	39	Sick and black tip fungus.
JULY 14, 1937														
----	----	----	----	----	----	----	----	None	Combine	89	71	69.2	39	
----	----	----	----	----	----	----	----	do	do	89	71	69.2	39	
----	----	----	----	----	----	----	----	do	do	89	71	69.2	39	Bin found to be not airtight "no accumulation of CO_2"
JULY 4, 1938														
15.1	14.5	91	82	18	15	----	----	None	Commercial	83	78	77.5	77	Shipped from St. Louis, Mo. (aerated from July 1 to July 4).
14.7	14.4	----	82	25	20	----	----	do	do	83	78	77.5	77	Fumigated with chlorosol Aug. 26, 1938, Sept. 20, 1938, and Nov. 19, 1938.
15.6	13.6	88	67	23	20	----	----	do	do	83	78	77.5	77	
15.0	13.2	81	30	30	22	----	----	do	do	83	78	77.5	77	
15.3	13.0	60	8	41	26	----	----	do	do	83	78	77.5	77	

TABLE 41.—*Condition and quality of wheat, harvest method, admixtures, variations at Urbana in 1936*

Storage period when sampled (days)[1]	Portion of bulk sampled	Official grade of sample [2]	Moisture content	Test weight per bushel	Weight per 1,000 kernels	Dockage	Total damaged kernels	Normal germination	Fat acidity [3]	Odor	Fumigated	Weevil and other insect infestation
			Pct.	*Lb.*	*Gm.*	*Pct.*	*Pct.*	*Pct.*	*Units*			
BIN U-3, FILLED												
1	Average	2, Garlicky, Tough	14.7	59.8	35.0	0.3	0.6	84	19	Natural	No	None
58	do	2, Light garlicky, Tough.	14.7	59.5		.4	1.0	46	22	Fumigant	Yes	do
367	do	Sample, Light garlicky, Tough.	15.2	57.4		.4	18.0	8	38	Musty	Yes	Insects
393+160	do	Sample	13.9	58.2		.5	21.0	33	42	Fumigant	Yes	Weevils
BIN U-4, FILLED												
1	Average	2, Light garlicky, Tough.	14.8	59.9	33.0	0.3	2.0	74	20	Natural	No	None
58	do	do	14.8	59.6			1.5	85	21	Fumigant	Yes	do
70	do	Sample, Light garlicky, Tough.	14.7	59.5				81	21	Musty	Yes	Insects
70+18	do	do	14.0	59.4		.5		73	24	do	Yes	do
BIN U-5, FILLED												
0	Average	2, Light garlicky, Tough. [7]	14.5	59.6	32.2	0.3	(6)	81	19	Natural	No	None
26	do	2, Light garlicky [7]	13.9	59.8		.3	(6)	90	16	do	Yes	do
83	do	do [7]	13.8	59.8	32.2		(6)	68	20	Weevily	Yes	Weevils
BIN U-29, FILLED												
3	Average	1, Tough [7]	14.7	60.5	30.0	0.4	(6)	87	19	Natural	No	None
542	do	do [7]	14.3	60.0		.4	0.8	81	26	do	Yes	do
1,000	do	2, Tough [7]	15.1	58.9		.3	3.0			do	Yes	do

in quality throughout bin and temperature data of wheat stored in experimental bins 1937, and 1938—Continued

Variations shown in other portions of bulk at same storage period								Admixtures	Harvest method or source of wheat	First "maximum" temperature period" in center of bulk [4]				Remarks
Moisture		Normal germination		Fat acidity [3]		Total damaged kernels				Initial temperature	"Final" temperature	Average temperature	Length of period	
Maximum	Minimum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum							
Pct.	*Pct.*	*Pct.*	*Pct.*	*Units*	*Units*	*Pct.*	*Pct.*			*° F.*	*° F.*	*° F.*	*Dy.*	
JULY 4, 1938														
15.0	14.5	91	----	------	16	----	----	None	Commercial	81	80	79.0	74	Shipped from St. Louis, Mo.
14.9	14.2	68	10	23	20	----	----	do	do	81	80	79.0	74	Fumigated with chloropicrin Aug. 26, 1938, Sept. 20, 1938, and Nov. 19, 1938.
16.9	14.2	43	1	67	20	40.0	3.0	do	do	81	80	79.0	74	
14.8	13.0	36	11	50	31	----	----	do	do	81	80	79.0	74	Wheat removed, cleaned, and returned Aug. 2, 1939.
JULY 4, 1938														
15.2	14.5	91	----	22	15	----	----	None	Commercial	85	92	85.4	70	Shipped from St. Louis, Mo. Damage from sample submitted at same time for milling.
15.4	14.6	92	56	27	20	----	----	do	do	85	92	85.4	70	Fumigated with carbon disulphide Aug. 26, 1938, and Sept. 20, 1938. Damage from sample submitted at same time for milling.
15.8	----	----	8	32	19	10.0	----	do	do	85	92	85.4	70	
14.7	11.2	82	42	31	20	----	----	do	do	85	92	85.4	70	Inferior portion removed, dried, and returned to bin.
JULY 9, 1938														
15.0	14.1	90	72	19	16	----	----	None	Combine	77	96	81.5	83	
14.5	12.8	----	67	18	14	----	----	do	do	77	96	81.5	83	Fumigated with chloropicrin Aug. 26, 1938, and Sept. 20, 1938.
14.4	13.3	88	32	23	17	----	----	do	do	77	96	81.5	83	
JULY 9, 1938														
----	14.4	91	----	------	17	----	----	None	Commercial	90	77	75.0	66	
14.5	15.2	91	----	------	24	----	----	do	do	90	77	75.0	66	Fumigated with chlorosol Nov. 19, 1938.
----	----	----	----	------	------	----	----	do	do	90	77	75.0	66	

TABLE 41.—*Condition and quality of wheat, harvest method, admixtures, variations at Urbana in 1936,*

Storage period when sampled (days)[1]	Portion of bulk sampled	Official grade of sample[2]	Moisture content	Test weight per bushel	Weight per 1,000 kernels	Dockage	Total damaged kernels	Normal germination	Fat acidity[3]	Odor	Fumigated	Weevil and other insect infestation
			Pct.	*Lb.*	*Gm.*	*Pct.*	*Pct.*	*Pct.*	*Units*			
BIN U-30, FILLED												
0	Average	1[8]	12.7	60.9	30.9	0.2	(6)	86	17	Natural	No	None
55	do	1[8]	12.6	60.3		.2	(6)	51	23	Fumigant	Yes	do
543	do	1[8]	13.1	60.0		.3	1.0	37	23	Natural	Yes	Insects
823	do	Sample, Weevily[8]	13.4	59.0		.3	2.0	20	32	Musty	Yes	do
BIN U-31, FILLED												
0	Average	1[8]	12.7	60.7	31.1	0.2	(6)	86	21	Natural	No	None
55	do	1[8]	12.6	60.2		.2	(6)	88	22	Fumigant	Yes	do
543	do	1[8]	13.1	60.0		.4	0.9	65	22	Natural	Yes	do
823	do	Sample, Weevily[8]	13.4	59.2		.4	5.0	26	31	Musty	Yes	Insects
BIN U-32, FILLED												
0	Average	1[8]	11.2	60.5		0.2	(6)	87	13	Natural	No	None
55	do	1[8]	11.4	60.2		.2	(6)	52	18	Fumigant	Yes	do
543	do	2[8]	12.2	59.5		.4	1.0	53	18	Natural	Yes	Weevils
999	do	2, Weevily[8]	13.1	59.0		.4	3.8			do	Yes	do
BIN U-33, FILLED												
0	Average	1[8]	11.3	60.6	31.2	0.3	(6)	87	15	Natural	No	None
55	do	1[8]	11.3	60.2		.2	(6)	80	15	Fumigant	Yes	do
543	do	1[8]	12.2	60.0		.4	0.9	82	20	Natural	Yes	do
999	do	4[8]	13.1	59.4		.3	5.7			do	Yes	do
BIN U-34, FILLED												
0	Average	1[8]	13.0	60.3	31.2	0.3	(6)	64	20	Natural	No	None
55	do	2[8]	12.9	59.8		.3	(6)	41	22	do	No	Insects
95	do	Sample[8]	12.8	58.8		.7	7.0	50	28	Musty	No	Weevils
543	do	do[8]	13.2	56.6		.4	20.0	4	40	do	Yes	do

See footnotes at end of table.

in quality throughout bin and temperature data of wheat stored in experimental bins 1937, and 1938—Continued

JULY 7, 1938

Variations shown in other portions of bulk at same storage period								Admixtures	Harvest method or source of wheat	First "maximum temperature period" in center of bulk [4]				Remarks
Moisture		Normal germination		Fat acidity [3]		Total damage kernels				Initial temperature	"Final" temperature	Average temperature	Length of period	
Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum							
Pct.	*Pct.*	*Pct.*	*Pct.*	*Units*	*Units*	*Pct.*	*Pct.*			°*F.*	°*F.*	°*F.*	*Dy.*	
----	12.4	90	----	------	12	----	----	None	Commercial	93	87	85.2	36	
----	12.3	62	----	24	22	----	----	do	do	93	87	85.2	36	Fumigated with chloropicrin Aug. 26, 1938.
13.2	13.0	50	29	------	20	----	----	do	do	93	87	85.2	36	
13.1	11.7	28	22	------	------	----	----	do	do	93	87	85.2	36	

JULY 7, 1938

----	12.4	----	84	------	15	----	----	None	Commercial	94	87	85.3	36	
12.7	12.2	----	81	23	22	----	----	do	do	94	87	85.3	36	Fumigated with carbon disulphide Aug. 26, 1938, and with chlorosol Nov. 19, 1938.
13.2	13.0	76	54	22	20	----	----	do	do	94	87	85.3	36	
13.1	12.6	37	24	------	------	----	----	do	do	94	87	85.3	36	

JULY 7, 1938

11.3	----	----	81	15	11	----	----	None	Combine	94	86	84.0	36	Fat acidity of sample drawn Aug. 4, 1938.
11.5	----	69	43	22	------	----	----	do	do	94	86	84.0	36	Fumigated with chloropicrin Aug. 26, 1938.
----	11.4	59	46	19	17	----	----	do	do	94	86	84.0	36	
----	----	----	----	------	------	----	----	do	do	94	86	84.0	36	

JULY 7, 1938

11.4	----	88	85	------	11	----	----	None	Combine	94	87	84.2	36	Fat acidity of sample drawn Aug. 4, 1938.
11.5	11.1	84	79	17	------	----	----	do	do	94	87	84.2	36	Fumigated with chlorosol Aug. 26, 1938.
----	12.0	----	71	------	18	----	----	do	do	94	87	84.2	36	
----	----	----	----	------	------	----	----	do	do	94	87	84.2	36	

JULY 7, 1938

----	12.9	73	----	------	17	----	----	None	Combine	98	87	85.2	36	Germinations of sample drawn Aug. 4, 1938.
13.0	12.5	66	----	22	21	----	----	do	do	98	87	85.2	36	
----	11.9	69	43	------	------	----	----	do	do	98	87	85.2	36	Weevil bored and cut kernels. Dockage "flour from insect infestation."
13.6	13.1	5	2	41	39	----	----	do	do	98	87	85.2	36	Fumigated with chlorosol Nov. 19, 1938.

TABLE 41.—*Condition and quality of wheat, harvest method, admixtures, variations at Urbana in 1936.*

Storage period when sampled (days)[1]	Portion of bulk sampled	Official grade of sample [2]	Moisture content	Test weight per bushel	Weight per 1,000 kernels	Dockage	Total damaged kernels	Normal germination	Fat acidity [3]	Odor	Fumigated	Weevil and other insect infestation
			Pct.	*Lb.*	*Gm.*	*Pct.*	*Pct.*	*Pct.*	*Units*			
BIN U-35, FILLED												
0	Average	1 [8]	13.1	60.4	31.4	0.3	(6)	74	19	Natural	No	None
55	do	1 [8]	13.0	60.0		.3	(6)	60	20	do	No	do
134	do	Sample [8]	12.9	58.4			7.2	58	26	Musty	No	Weevils
543	do	do [8]	13.0	58.0		.8	8.5	21	35	do	Yes	do
BIN U-36, FILLED												
2	Average	1 [9]	12.5	60.2	25.9	0.3	(6)	81	19	Natural	No	None
53	do	2 [9]	12.5	59.6			(6)	0	17	Fumigant	Yes	do
541	do	2 [9]	12.7	59.2		.4	0.8		20	do	Yes	do
997	do	2 [9]	13.2	59.0		.3	1.0			Natural	Yes	do
BIN U-37, FILLED												
2	Average	1 [9]	12.4	60.2	26.2	0.3	(6)	84	15	Natural	No	None
53	do	1 [9]	12.4	60.0		.3	(6)	80	15	Fumigant	Yes	Insects
541	do	2 [9]	12.8	59.3		.4	1.0	86	20	Natural	Yes	None
998	do	4, Weevily [9]	12.6	58.9		.4	1.5			do	Yes	Insects
BIN U-38, FILLED												
1	Average	1 [8]	14.2	60.1	30.4	0.2	(6)	94	16	Natural	No	None
55	do	2 [8]	14.0	59.6		.3	(6)	77	18	Fumigant	Yes	do
542	do	2 [8]	13.8	58.6		.4	3.8	23	27	Natural	Yes	do
725	do	Sample, Weevily [8]	13.4	58.9		.4	8.0	12	34	Musty	Yes	Insects
BIN U-39, FILLED												
1	Average	2, Tough [8]	14.2	59.9	31.4	0.2	(6)	92	17	Natural	No	None
55	do	do. [8]	14.1	59.6		.4	(6)	12	18	Fumigant	Yes	do
543	do	3 [8]	14.0	58.5		.4	6.0	5	27	do	Yes	Insects
822	do	Sample, Weevily [8]	13.5	58.7		.4	16.5	2	36	Musty	Yes	do

See footnotes at end of table.

in quality throughout bin and temperature data of wheat stored in experimental bins 1937, and 1938—Continued

Variations shown in other portions of bulk at same storage period								Admixtures	Harvest method or source of wheat	First "maximum" temperature period" in center of bulk [4]				Remarks
Moisture		Normal germination		Fat acidity [3]		Total damaged kernels								
Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum			Initial temperature	"Final" temperature	Average temperature	Length of period	
Pct.	*Pct.*	*Pct.*	*Pct.*	*Units*	*Units*	*Pct.*	*Pct.*			*°F.*	*°F.*	*°F.*	*Dy.*	
JULY 7, 1938														
----	12.8	----	55	26	------	----	----	None	Combine	97	87	85.8	36	Germination of sample drawn Aug. 4, 1938.
----	12.4	----	54	23	21	----	----	do	do	97	87	85.8	36	
13.1	12.0	62	50	------	------	----	----	do	do	97	87	85.8	36	Weevil bored and cut kernels.
13.2	12.8	33	15	------	28	----	----	do	do	97	87	85.8	36	Fumigated with chlorosol Nov. 19, 1938.
JULY 9, 1938														
----	12.3	85	78	20	17	----	----	None	Combine	92	87	84.2	34	
12.7	12.2	3	----	19	------	----	----	do	do	92	87	84.2	34	Fumigated with methyl bromide Aug. 26, 1938.
12.9	12.2	4	----	21	20	----	----	do	do	92	87	84.2	34	
----	----	----	----	------	------	----	----	do	do	92	87	84.2	34	
JULY 9, 1938														
12.6	12.2	88	----	19	------	----	----	None	Combine	93	87	86.0	34	Fat acidity of sample drawn Aug. 4, 1838.
12.5	11.9	88	----	16	15	----	----	do	do	93	87	86.0	34	Fumigated with one part carbon disulphide and three parts carbon tetrachloride on Aug. 26, 1938.
12.9	12.6	----	84	22	------	----	----	do	do	93	87	86.0	34	Fumigated with chlorosol on Nov. 19, 1938.
----	----	----	----	------	------	----	----	do	do	93	87	86.0	34	
JULY 8, 1938														
15.2	14.1	95	91	16	15	----	----	None	Combine	96	87	85.0	35	Fat acidity of sample drawn Aug. 5, 1938.
----	13.1	91	----	19	18	----	----	do	do	96	87	85.0	35	Fumigated with carbon disulphide on Aug. 26, 1938.
14.1	13.3	38	----	29	24	----	----	do	do	96	87	85.0	35	Fumigated with chlorosol on Nov. 19, 1938.
13.6	11.4	22	16	30	25	----	----	do	do	96	87	85.0	35	
JULY 8, 1938														
14.4	14.1	----	90	------	15	----	----	None	Combine	96	86	84.8	35	
----	13.0	32	----	19	16	----	----	do	do	96	86	84.8	35	Fumigated with methyl bromide on Aug. 26, 1938.
14.2	13.2	9	----	------	24	----	----	do	do	96	86	84.8	35	
----	----	----	----	------	------	----	----	do	do	96	86	84.8	35	

TABLE 41.—*Condition and quality of wheat, harvest method, admixtures, variations at Urbana in 1936*

Storage period when sampled (days) [1]	Portion of bulk sampled	Official grade of sample [2]	Moisture content	Test weight per bushel	Weight per 1,000 kernels	Dockage	Total damaged kernels	Normal germination	Fat acidity [3]	Odor	Fumigated	Weevil and other insect infestation
			Pct.	*Lb.*	*Gm.*	*Pct.*	*Pct.*	*Pct.*	*Units*			
BIN U-40, FILLED												
2	Average	1 [4]	13.4	60.1	30.4	0.2	(6)	91	16	Natural	No	None
54	do	2 [4]	13.2	59.7			(6)	85	17	Fumigant	Yes	do
542	do	2 [4]	13.2	59.2		.4	0.7	65	22	do	Yes	Insects
821	do	Sample, Weevily [4]	12.8	59.0		.4	14.0	28	29	Musty	Yes	do
BIN U-41, FILLED												
2	Average	1 [4]	13.4	60.1	30.4	0.2	(6)	88	18	Natural	No	None
54	do	2 [4]	13.2	59.8		.2	(6)	88	18	Fumigant	Yes	do
542	do	2 [4]	13.2	59.3		.4	0.8	72	22	Natural	Yes	do
998	do	2 [4]	13.1	59.0		.3	1.0			do	Yes	Insects

[1] Plus sign (+) indicates that grain was moved after previous sampling. Total storage period for any sample is sum of figures, added horizontally.
[2] All wheat of class Soft Red Winter and subclass Red Winter except where noted.
[3] Fat acidity, for all samples drawn in 1936, was calculated from the acid value determination and average oil content of soft red winter wheat.
[4] Ordinarily if newly harvested wheat heats in the bin it is during the initial storage period. The temperature data given are only the period stated in the length of period column.

in quality throughout bin and temperature data of wheat stored in experimental bins 1937, and 1938—Continued

JULY 9, 1938

Variations shown in other portions of bulk at same storage period								Admixtures	Harvest method or source of wheat	First "maximum temperature period" in center of bulk [4]				Remarks
Moisture		Normal germination		Fat acidity [3]		Total damaged kernels				Initial temperature	"Final" temperature	Average temperature	Length of period	
Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum							
Pct.	*Pct.*	*Pct.*	*Pct.*	*Units*	*Units*	*Pct.*	*Pct.*			*°F.*	*°F.*	*°F.*	*Du.*	
----	13.3	----	89	16	------	----	----	None	Combine	88	87	84.5	34	
----	12.7	89	84	------	16	----	----	do	do	88	87	84.5	34	Fumigated with one part carbon disulphide and three parts carbon tetrachloride on Aug. 26, 1938.
13.3	13.0	76	38	24	21	----	----	do	do	88	87	84.5	34	Fumigated with chlorosol on Nov. 19, 1938.
12.7	11.5	36	29	------	------	----	----	do	do	88	87	84.5	34	

JULY 9, 1938

----	13.3	----	87	------	17	----	----	None	Combine	87	87	84.2	34	
13.1	12.6	----	81	19	17	----	----	do	do	87	87	84.2	34	Fumigated with chlorosol on Aug. 26, 1938 and Nov. 19, 1938.
13.5	12.5	----	48	23	16	----	----	do	do	87	87	84.2	34	
----	----	----	----	------	------	----	----	do	do	87	87	84.2	34	

[5] Commercially objectionable foreign odor.
[6] Trace.
[7] Wheat of class mixed and subclass mixed wheat.
[8] Wheat of class Hard Red Winter and subclass Yellow Hard Winter.
[9] Wheat of class Hard Red Winter and subclass Hard Winter.

TABLE 42.—*Description of bins and quality of wheat as*

BINS IN

Bin No.	County	Location of bin	Roof type	Bin surfaces contacting wheat: Floor: Material	Bin surfaces contacting wheat: Walls: Material	Bin surfaces contacting wheat: Walls: Number exposed to sun	Bulk measurement: Quantity	Bulk measurement: Average depth	Bulk measurement: Half minimum width
							Bu.	*Ft.*	*Ft.*
F-51	Traill	Granary	Wood shingle	Concrete	Wood	2	682	6.6	5.2
F-51									
F-52	do	do	do	Wood	do	2	440	7.0	3.5
F-52									
F-53	do	do	do	do	do	1	614	6.0	4.0
F-53									
F-54	do	Outdoors	Metal	Metal	Metal	(2)	923	7.5	7.0
F-54									
F-55	Cass	Granary	Wood shingle	Wood	Wood	1	392	5.0	4.5
F-55									
F-57	Traill	do	do	Concrete	do	2	768	8.0	5.0
F-57									
F-58	do	do	do	Wood	do	2	880	5.0	5.0
F-58									
F-59	do	do	Ceiling	do	do	2	189	5.0	2.6
F-59									
F-60	Cass	Outdoors	Metal	Metal	Metal	(2)	862	7.0	7.0
F-60									
F-61	do	Granary	Wood shingle	Wood	Wood	0	358	7.0	4.0
F-61									
F-62	do	do	do	Concrete	do	2	537	7.0	4.0
F-62									
F-63	do	Stock barn	Ceiling	do	do	2	453	7.0	4.5
F-63									
F-64	do	Granary	Wood shingle	Wood	do	2	256	5.0	4.0
F-64									
F-65	Traill	do	do	Concrete	do	2	386	6.0	3.5
F-65									
F-66	do	do	do	Wood	do	3	1,730	5.0	9.0
F-66									

BINS IN

M-51	Norman	Granary	Wood shingle	Wood	Wood	2	864	10.0	4.5
M-52	do	do	do	do	Wood-lined metal.	2	475	9.0	2.7
M-53	Polk	do	Roll	do	Wood	2	921	8.0	4.5
M-54	do	do	Wood shingle	Concrete	do	2	512	8.0	4.0
M-55	do	do	do	Wood	do	2	291	7.0	3.2
M-56	do	do	do	do	do	3	784	7.0	5.0
M-57	do	do	Ceiling	do	do	2	941	14.0	3.0
M-58	Norman	do	Wood shingle	do	do	2	1,056	10.0	5.5
M-59	do	do	do	do	do	2	576	6.0	5.0
M-60	Polk	Outdoors	Metal	Metal	Metal	0	985	8.0	7.0
M-61	do	Granary	Ceiling	Wood	Wood	2	1,300	6.0	7.5
M-62	Norman	do	Wood shingle	do	do	2	907	9.0	4.5
M-63	Polk	do	do	do	do	1	360	5.0	3.7
M-64	Norman	do	do	do	do	1	528	6.0	5.0
M-65	Polk	Outdoors	Metal	Metal	Metal	(2)	985	8.0	7.0

See footnotes at end of table.

observed from average samples taken in survey of 1936

NORTH DAKOTA [1]

Harvest method or source of wheat	Initial wheat temperature	Date filled	Storage period when sampled	Official grade of sample	Moisture content	Test weight per bushel	Weight per 1,000 kernels	Dockage	Total damaged kernels	Normal germination	Odor
	°F.		Days		Pct.	Lb.	Gm.	Pct.	Pct.	Pct.	
Combine	92	July 29	1	3	10.1	56.5	20.3	0.3	0	90	Natural.
			93	3	9.4	56.5		.3			Do.
Combine and threshed.	88	July 24	1	4	10.4	54.6	19.7	1.0	.1	76	Do.
			98	4	10.1	54.4		1.0			Do.
Threshed	89	Aug. 1	2	3	8.4	55.7	21.1	2.0	0	80	Do.
			90	3	8.7	55.8		2.1			Do.
do	74	July 29	1	3	9.5	56.0	21.3	1.7	0	80	Do.
			93	3	9.4	55.9		2.0			Do.
do	92	Aug. 5	1	3	8.3	55.2	20.0	1.1	0	94	Do.
			86	3	9.0	55.0		.9			Do.
Combine	95	Aug. 4	1	3	7.2	56.2	21.4	1.1	0	89	Do.
			87	3	8.3	56.3		1.1			Do.
do	96	July 27	1	3	10.2	55.1	20.3	1.0	0	92	Do.
			95	4	9.2	54.5		1.3			Do.
Threshed	83	July 28	0	3	10.2	55.8	20.4	1.0	0	91	Do.
			67	3	9.4	55.8		1.0	.1	93	Do.
Combine	94	July 27	0	3	10.8	55.0	20.3	.8	0	81	Do.
			95	3	9.0	55.0		.7			Do.
Threshed	80	Aug. 4	1	3	8.5	56.0	21.6	4.7	0	81	Do.
			87	3	8.3	55.7		3.9			Do.
Combine	91	July 29	1	3	11.5	56.0	21.0	.5	.2	95	Do.
			93	3	11.8	55.0		.6			Do.
do	94	do	1	3	9.8	55.8	20.5	1.7	.1	91	Do.
			93	3	9.8	55.9		1.2			Do.
Threshed	77	Aug. 8	2	3	8.9	55.5	19.4	5.5	.1	79	Do.
			83	3	9.0	55.3		5.5			Do.
Combine	92	Aug. 1	2	3	9.0	56.7	21.0	1.6	0	81	Do.
			90	3	10.3	56.7		1.7			Do.
do	78	July 29	2	5	9.5	51.5	18.1	1.8	0	74	Do.
			93	5	9.2	51.4		2.1			Do.

MINNESOTA [1]

Threshed	88	July 31	1	3	7.8	56.0	19.5	1.1	0.1	79	Natural.
			88	3	7.7	55.6		.8			Do.
do	93	do	1	4	9.5	54.7	19.4	2.3	.1	88	Do.
			98	4	9.2	54.1		2.3			Do.
do	93	Aug. 1	2	3, Smutty	8.8	55.8	20.0	1.6	0	79	Smutty.
			97	3	8.7	55.7		1.7			Natural.
Combine	91	Aug. 6	1	1	8.3	58.0	21.2	1.0	0	79	Do.
			92	2	8.8	57.6		1.6			Do.
Threshed	72	Aug. 4	1	2	8.3	57.5	21.4	2.5	.3	95	Do.
			94	2	8.4	57.0		2.5			Do.
do	80	Aug. 3	2	3	8.3	55.0	18.9	1.2	.1	92	Do.
			86	4	8.4	54.6		1.4	(3)	90	Do.
do	88	Aug. 13	1	5	7.7	51.5		1.0	(3)	90	Do.
			85	5	7.6	51.6		1.1			Do.
do	71	Aug. 4	1	4	8.5	54.5	18.1	1.3	0	90	Do.
			94	4	9.0	53.3		1.9			Do.
do	85	Aug. 6	1	2	8.9	57.3	20.7	.8	.1	92	Do.
			92	3	9.0	56.7		1.0			Do.
do	77	do	1	3	8.8	55.8	19.9	1.0	(3)	94	Do.
			92	3	8.7	55.2		.8			Do.
do	87	Aug. 2	1	4	8.4	53.5	16.9	1.5	.2	88	Do.
			96	4	8.7	53.3		1.6			Do.
do	80	Aug. 3	1	5	8.6	51.2		2.0	.1	86	Do.
			95	5	8.3	51.1		2.2			Do.
do	93	Aug. 4	0	3	7.9	56.0		2.2	0	90	Do.
			94	3	7.7	55.7		2.2			Do.
do	80	Aug. 3	1	4	8.1	53.8		1.4	0	85	Do.
			95	4	8.3	53.6		1.3			Do.
do	84	Aug. 6	1	5	8.5	51.3		3.1	.1	76	Do.
			92	5	8.7	51.1		2.6			Do.

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TABLE 42.—*Description of bins and quality of wheat as observed*

Bin No.	County	Location of bin	Roof type	Bin surfaces contacting wheat: Floor: Material	Bin surfaces contacting wheat: Walls: Material	Bin surfaces contacting wheat: Walls: Number exposed to sun	Bulk measurement: Quantity	Bulk measurement: Average depth	Bulk measurement: Half minimum width
BINS IN									
							Bu.	*Ft.*	*Ft.*
H-51	Sedgwick	Stock barn	Ceiling	Concrete	Wood	1	716	7.0	4.0
H-52	do	Granary	Wood shingle	Wood	do	3	320	6.0	3.0
H-53	do	do	do	do	do	2	652	7.0	3.7
H-54	do	Stock barn	Ceiling	do	do	2	678	7.0	5.5
H-55	do	Outdoors	Metal	Metal	Metal	(2)	985	8.0	7.0
H-56	do	Granary	Wood shingle	Wood	Wood	3	828	7.6	4.5
H-57	do	Outdoors	Metal	Metal	Metal	(2)	400	3.2	7.0
H-58	do	Elevator	Wood shingle	Wood	Wood-lined metal	2	600	12.0	3.7
H-59	do	Outdoors	Boxcar	do	Wood	3	1,090	8.0	4.5
H-60	do	Granary	Ceiling	do	do	1	615	9.0	4.5
H-61	do	Outdoors	Metal	Metal	Metal	(2)	1,000	7.5	7.2
H-62	do	Granary	Wood shingle	Wood	Wood	2	547	9.0	4.0
H-63	do	do	do	do	do	3	845	5.5	6.0
H-64	do	do	Metal	do	Wood-lined metal.	1	900	6.0	5.5
H-65	do	Outdoors	do	Metal	Metal	(2)	500	4.1	6.7
H-66	do	do	do	Concrete	do	(2)	475	3.8	7.0
H-67	do	Stock barn	Ceiling	Wood	Wood	1	350	8.0	6.0
H-68	do	Outdoors	Metal	Metal	Metal	1	947	9.6	6.2
H-69	do	do	do	do	do	(2)	440	7.5	4.7
H-70	do	do	do	do	do	(2)	440	7.5	4.7
H-71	do	do	do	Wood on concrete.	do	(2)	1,270	9.0	7.5
H-72	do	Granary	Wood shingle	Concrete	Wood	1	691	8.0	4.0
H-73	do	do	do	Wood	do	1	806	8.0	5.2
H-74	do	Stock barn	do	do	do	1	1,260	7.0	7.5
H-75	do	Granary	do	do	do	2	1,200	5.0	7.0
BINS IN									
U-51	Madison	Granary	Metal	Wood	Wood	2	480	6.6	4.0
U-52	do	Stock barn	Ceiling	do	do	1	535	4.6	5.5
U-53	do	Granary	do	do	do	2	1,660	5.7	4.5
U-54	do	do	Wood shingle	do	do	2	214	3.0	4.2
U-55	do	do	do	do	do	2	257	3.2	4.5

See footnotes at end of table.

from average samples taken in survey of 1936—Continued

KANSAS [4]

Harvest method or source of wheat	Initial wheat temperature	Date filled	Storage period when sampled	Official grade of sample	Moisture content	Test weight per bushel	Weight per 1,000 kernels	Dockage	Total damaged kernels	Normal germination	Odor
	°F.		Days		Pct.	Lb.	Gm.	Pct.	Pct.	Pct.	
Combine	103	June 22	1	2	9.3	58.6	22.0	0.8	0.1	92	Natural
			172	2	9.2	58.8		.9	.1		Do.
do	103	June 20	0	1	9.5	61.0	25.0	.4	.3	95	Do.
			332	1	9.6	61.0		.4	.2		Do.
do	94	do	0	1	9.8	60.5	24.0	.6	.3	94	Do.
			282	1	9.6	60.2			.3	90	Do.
do	91	do	0	1	11.3	60.6	23.5	.3	.2	81	Do.
			96	1 [5]	13.0	60.0		.6		91	Do.
do	107	do	0	1 [6]	9.8	61.3	24.5	.5	.3	81	Do.
			174	1 [6]	10.2	61.3		.5	.3		Do.
Threshed	89	June 27	2	1 [7]	8.5	62.0	26.0	.2	.1	91	Do.
			89	1 [7]	8.9	61.6		.2		78	Do.
Combine	102	June 23	0	1	9.3	61.7	24.1	.3	(3)	88	Do.
			171	1	10.3	61.7		.2	(3)		Do.
do	92	June 16	4	1	10.4	60.8	24.1	.2	.5	92	Do.
			178	1	11.1	60.5		.2	.5		Do.
do	99	June 20	0	2	9.4	59.0	26.7	.5	(3)	92	Do.
			174	2	9.6	59.1		.4	(3)		Do.
do	90	June 22	3	2	10.1	59.8	27.6	1.1	(3)	76	Do.
			94	2	10.8	59.8		1.5		91	Do.
do	100	June 23	1	1	9.0	62.0	27.8	.2	.1	89	Do.
			93	1	9.0	61.1		.2		89	Do.
do	100	June 26	4	1	9.2	61.8	27.1	.5	.4	90	Do.
			90	1	9.9	61.5		.6		92	Do.
do	98	June 20	0	1	11.1	61.3	25.1	.2	.4	80	Do.
			101	1	10.9	61.8		.2		84	Do.
do	87	June 25	5	1	9.5	62.7	27.4	.2	(3)	90	Do.
			96	1	9.4	61.6		.2		94	Do.
do	107	June 23	1	2	12.4	59.5	22.5	1.4	.6	86	Do.
			63	1	10.6	60.0		.5		83	Do.
do	91	June 26	4	3	9.3	56.8	23.0	.8	.2	92	Do.
			95	3 [5]	10.6	56.5		.7		96	Do.
do	81	July 1	2	2	11.4	59.6	23.5	.8		93	Do.
			90	2	11.7	59.3		.9		93	Do.
do	97	June 24	0	1	9.2	60.2	26.3	.3	(3)	89	Do.
			62	1 [5]	9.1	60.4		.4		95	Do.
do	87	June 25	0	1	9.2	60.3	24.0	.6	.1	93	Do.
			96	1 [5]	9.2	60.3		.5		95	Do.
do	101	June 24	1	1	9.3	61.0	26.7	.1	.1	90	Do.
			166	1	9.2	61.0		.2	.1		Do.
do	84	June 22	8	1	9.4	61.6	27.0	.3	(3)	93	Do.
			99	1 [5]	9.5	61.1		.2		90	Do.
do	98	June 24	1	2	9.3	61.8	27.2	.2		96	Do.
			97	3	9.2	61.8		.2		97	Do.
do	101	June 25	0	2	10.1	59.7	22.1	.2		84	Do.
			96	2	9.9	59.6		.2		89	Do.
do	90	June 27	3	1	8.1	61.1	26.9	.2	(3)	92	Do.
			163	1	8.8	60.7		.3	(3)	88	Do.
do	85	June 24	6	1	11.0	60.3	24.3	2.0	.1	91	Do.
			68	1	10.6	60.2		1.7		78	Do.

ILLINOIS [8]

Threshed	99	July 14	2	2	9.7	58.2	33.7	1.2	0.1	96	Natural.
			147	2	10.0	58.2		1.3	.1	91	Do.
do	97	July 13	2	1	9.6	60.1	34.5	.2	(3)	91	Do.
			78	2	9.8	59.4		.3		95	Do.
do	98	July 10	0	2	10.7	59.8	34.4	.2	(3)	92	Do.
			152	2	10.8	59.3		.2	(3)	88	Do.
do	90	July 8	0	3	11.0	59.7	36.0	.4	.3	91	Do.
			83	3	11.1	59.3				93	Do.
do	91	July 9	1	2	10.9	60.5	32.6	1.0	.2	89	Do.
			92	2	11.6	60.0		1.5	.1	82	Do.

TABLE 42.—*Description of bins and quality of wheat as observed*

Bin No.	County	Location of bin	Roof type	Bin surfaces contacting wheat: Floor: Material	Bin surfaces contacting wheat: Walls: Material	Bin surfaces contacting wheat: Walls: Number exposed to sun	Bulk measurement: Quantity	Bulk measurement: Average depth	Bulk measurement: Half minimum width
BINS IN									
							Bu.	*Ft.*	*Ft.*
U-56	Madison	Machine shed	Wood shingle	Wood	Wood	0	300	3.2	5.2
U-58	do	Granary	do	do	Logs	2	498	2.9	5.5
U-59	St. Clair	Stock barn	Ceiling	do	Wood	1	293	3.7	4.2
U-60	do	Granary	Metal	do	do	1	391	3.7	4.5
U-61	do	Stock barn	Ceiling	do	do	1	525	2.5	7.5
U-62	Washington	Granary	Wood shingle	Wood	Wood	1	306	6.9	3.5
U-63	do	do	Ceiling	do	do	1	718	4.6	6.0
U-64	do	do	do	do	do	2	325	4.5	4.5
U-65	Christian	Outdoors	Metal	Metal	Perforated metal.	(2)	345	8.5	4.0
U-66	do	Stock barn	Ceiling	Concrete	Wood	1	332	6.2	3.5
U-69	Macoupin	Granary	Wood shingle	Wood	do	2	313	4.3	4.7
U-70	St. Clair	do	Ceiling	do	do	1	472	3.0	6.7
U-71	do	do	Roll	do	Wood-lined metal.	1	402	6.3	4.3
U-72	Madison	do	Wood shingle	do	Wood	1	730	8.3	4.7
U-75	Champaign	Outdoors	Box car	do	do	3	205	4.0	4.0
U-76	do	Granary	Ceiling	do	do	1	500	6.5	3.0
U-77	do	Stock barn	do	do	do	0	460	4.0	6.0
U-79	do	Granary	do	do	do	1	1,680	6.0	7.0
U-80	do	Stock barn	do	do	do	0	576	6.0	5.0
U-81	do	Outdoors	Wood shingle	Concrete	do	(2)	960	5.0	7.5
U-82	do	Granary	Metal	Wood	do	0	470	3.5	6.0
U-83	do	do	Ceiling	do	do	1	384	4.0	5.0
BINS IN									
T-51	Wood	Granary	Ceiling	Wood	Wood	2	160	5.0	3.0
T-51A	do	do	do	do	do	1	350	5.0	3.0
T-52	do	Stock barn	do	do	do	0	435	6.0	3.5
T-53	do	Granary	Wood shingle	do	do	3	371	7.5	3.3
T-54	do	do	Ceiling	do	do	3	730	8.0	4.7
T-55	do	do	Metal	do	do	1	255	5.0	3.0
T-56	do	Stock barn	Ceiling	do	do	1	250	3.3	3.0
T-57	do	Granary	Wood shingle	do	do	1	192	4.0	3.0
T-58	do	do	Roll	do	do	2	345	6.0	3.0

See footnotes at end of table.

from average samples taken in survey of 1936—Continued

KANSAS[4]—Continued

Harvest method or source of wheat	Initial wheat temperature	Date filled	Storage period when sampled	Official grade of sample	Moisture content	Test weight per bushel	Weight per 1,000 kernels	Dockage	Total damaged kernels	Normal germination	Odor
	°F.		Days		Pct.	Lb.	Gm.	Pct.	Pct.	Pct.	
Threshed	95	July 8	1	2	10.0	59.8	33.4	.7	.2	86	Natural.
			93	2	11.4	59.6		.7		80	Do.
do	92	July 17	1	2, garlicky	12.5	59.2	34.0	.5	.1	87	Do.
			125	do	10.8	58.8		.4	.2	97	Do.
do	92	July 4	2	2	12.1	59.2		.7	.1	92	Do.
			86	2	12.0	58.9		.9	.1	88	Do.
do	82	July 2	1	1	14.0	60.8	36.0	.3	.1	99	Do.
			41+47	1	13.6	60.4		.4	.1	89	Do.
do	96	June 29	2	1	13.4	60.0				91	Do.
			91	1	10.6	60.0		.9	.2	85	Do.
do	101	July 13	1	2	9.8	59.0	30.9	.8	(3)	95	
			79	2	9.8	58.6		.8		91	
do	97	do	1	1	9.6	60.2	29.2	.4	.1	95	
			148	2	9.5	59.8		.3	.2	90	
do	106	July 14	0	3, Garlicky	9.2	57.5	30.0	2.0	1.0	94	
			104	3, Garlicky	9.6	57.1		2.3	1.4	92	
do	96	July 17	1	2[9]	11.7	58.6	30.2	.1	.3	92	
			145	2[9]	12.0	58.4		.2	(3)	88	
do	95	July 14	4	1	9.2	61.7	33.2	.8	(3)	91	
			72	1	9.4	61.5		.7	(3)	82	Natural.
do	103	July 13	5	2	9.3	59.4	32.2	.6	.3	86	
			73	2	9.4	59.3		.4	.3	84	
do	98	July 4	2	1	11.0	60.9			.1	86	
			157	1	11.3	60.2		.2	.2	86	
do	92	do	3	2	11.6	59.2		.2	(3)	94	
			157	2	11.8	59.0		.2	.1	74	
do	84	July 22	1	2	11.0	59.2	32.3	.2	.2	94	
			72	2	11.1	58.9		.2	(3)	92	
Combine	114	July 14	1	1[10]	11.6	62.5	30.0	.1		92	
			13	(11)	17.5	59.5				27	Heating.
			13+141	1[10]	12.0	61.8		.2	.6		
do	100	July 11	2	1[12]	10.4	61.2	33.0	.2	(3)	87	
			80	1[12]	10.4	60.9		.3	(3)	94	
do	98	July 15	1	1[9]	9.4	60.1	33.5	.3	0	93	
			76	2[9]	10.6	59.2		.2	0	97	
do	99	July 11	6	1[12]	10.3	60.8	31.7	.4	0	97	
			80	1[12]	10.4	60.4		.2	0	97	Natural.
do	110	July 13	2	1[12]	10.9	60.8	32.1	.4	0	90	
			157	1[12]	9.4	60.6		.4			
Threshed	104	July 14	2	1[12]	10.3	62.0	32.0	.4	0	91	
			77	1[12]	9.9	61.8		.4	0	88	
Combine	104	July 13	1	1[12]	9.4	60.6	29.2	.3	(3)	96	
			78	1[12]	9.6	60.2		.2	0	93	
do	111	July 10	3	1[12]	9.5	60.0	30.0	.7	(3)	75	
			81	2[12]	9.3	59.4		.5	(3)	72	
OHIO											
Threshed	92	July 22	2	2[13]	9.9	61.1	37.8	0.7	0.2	87	
			110	1[13]	10.5	60.6	34.3	.8	.1	84	
do	96	July 13	1	1[13]	11.1	61.3	36.5	.3	.1	85	
			119	1[13]	11.2	61.1	32.8	.3	.1	93	
do	79	July 31	0	2[13]	12.5	59.7	38.2	.7	.1	81	
			180	2[13]	13.2	59.2	33.0	.4	.1	86	
do	80	July 20	0	2[14]	10.4	59.2	33.3	.8	.9	93	
			252	2[14]	11.0	58.9	32.0	.9	.6	94	
do	92	July 17	0	1[14]	10.7	60.1	33.7	1.6	.9	92	Natural.
			255	1[14]	11.8	60.2	33.5	.4	.5	91	
Combine	98	do	3	2[13]	11.3	59.0	35.7	1.1	.2	79	
			69	2[13]	11.6	58.8	34.1	1.2	.1	79	
Threshed	78	July 21	1	2[6]	9.8	58.0	28.4	3.4	.5	83	
			111	2[6]	11.2	58.6	28.0	3.5	.3	68	
do	81	do	1	2[6]	9.5	58.3	27.8	4.3	.7	87	
			111	2[6]	11.2	58.6	32.0	4.2	.4		
Combine	80	July 30	0	2, Tough[6]	14.9	57.0	28.9	2.1	.9	85	
			28	Sample, Tough[6]	14.9	56.6		3.0	8.6	72	Sour.

TABLE 42.—*Description of bins and quality of wheat as observed*

Bin No.	County	Location of bin	Roof type	Bin surfaces contacting wheat: Floor: Material	Bin surfaces contacting wheat: Walls: Material	Bin surfaces contacting wheat: Walls: Number exposed to sun	Bulk measurement: Quantity	Bulk measurement: Average depth	Bulk measurement: Half minimum width
BINS IN									
							Bu.	*Ft.*	*Ft.*
T-59A	Lucas	Stock barn	Ceiling	Wood	Wood	2	700	5.5	5.0
T-59B	do	do	do	do	do	1	269	3.5	3.0
T-59C	do	do	do	do	do	1	922	4.5	8.0
T-61	do	Granary	Roll	do	do	0	460	8.0	4.0
T-62	Wood	do	do	do	do	2	288	5.0	3.0
T-63	Lucas	Stock barn	Ceiling	do	do	0	180	6.0	2.5
T-64	do	Granary	Metal	do	do	0	369	6.0	2.7
BINS IN									
T-70	Lenawee	Granary	Wood shingle	Wood	Wood	2	235	6.0	3.5
T-71	do	do	do	do	do	(2)	576	1.1	9.0
T-73	Washtenaw	Stock barn	Ceiling	do	do	0	540	7.5	3.7
T-74	do	do	do	do	Wood-lined metal.	0	108	4.5	2.5
T-75	do	Granary	Wood shingle	do	Wood	1	162	4.5	3.0
T-77	do	Stock barn	Ceiling	do	do	2	105	5.5	2.0
T-78	do	do	do	do	do	1	170	4.5	3.0
T-79	do	do	do	do	Wood-lined metal.	2	247	5.5	3.5
T-80	do	do	do	do	Wood	2	130	5.1	2.2
T-84	do	do	do	do	do	2	259	6.0	3.0
BINS IN									
B-51	Washington	Stock barn	Ceiling	Wood	Wood	0	511	4.0	3.0
B-52	do	do	do	do	do	0	480	5.0	3.0
B-53	do	do	do	do	do	1	783	6.0	4.0
B-55	do	Granary	Metal	Concrete	do	1	352	5.5	4.0
B-56	do	Stock barn	Ceiling	Wood	Sacks	0	320	3.0	2.0
B-59	do	do	do	do	Wood	1	400	1.7	5.5
B-60	do	do	do	do	do	2	200	3.3	4.0
B-61	do	do	do	do	do	1	75	3.5	2.0

See footnotes at end of table.

from average samples taken in survey of 1936—Continued

OHIO—Continued

Harvest method or source of wheat	Initial wheat temperature	Date filled	Storage period when sampled	Official grade of sample	Moisture content	Test weight per bushel	Weight per 1,000 kernels	Dockage	Total damaged kernels	Normal germination	Odor
	°F.		Days		Pct.	Lb.	Gm.	Pct.	Pct.	Pct.	
Combine	108	July 15	1	2 [13]	10.4	58.7	31.1	0.3	0.5	91	Natural.
			258	2 [13]	10.8	58.7	31.3	.2	.3	89	
do	92	July 26	4	4 [6]	12.8	54.7	26.5	.3	.3	96	
			246	4 [6]	13.5	54.7	26.5	.4	.2	87	
do	86	July 16	1	3 [14]	10.7	57.5	30.8	1.9	.1	89	
			70	2 [14]	11.2	58.0	34.2	1.2	.3	87	
do	90	July 18	2	3 [14]	11.0	57.4	27.8	.8	.2	89	
			70	2 [5]	10.9	59.4	34.0	.3	.3	91	
do	84	July 22	8	3 [13]	12.6	57.7	33.8	4.0	.5	84	
			250	3 [13]	12.8	57.8	31.0	2.0	.5	91	
do	85	July 16	0	3 [14]	12.7	56.7	32.0	1.5	.2	93	
			70	3 [14]	12.6	57.0	33.3	1.5	.4	87	
do	102	July 14	2	2 [14]	11.1	59.1	30.0	.4	.4	84	
			118	2 [14]	11.2	59.2	33.4	.3	.2		

MICHIGAN

Harvest method or source of wheat	Initial wheat temperature	Date filled	Storage period when sampled	Official grade of sample	Moisture content	Test weight per bushel	Weight per 1,000 kernels	Dockage	Total damaged kernels	Normal germination	Odor
Threshed	84	July 27	0	3 [14]	12.4	57.3	35.6	0.2	0.4	84	Natural.
			108	3 [14]	12.4	57.2	31.0	.1	.7		
do	84	July 24	3	3 [14]	10.3	56.0	33.4	1.4	1.9	73	
			111	3 [14]	10.5	56.3	30.0	1.1	1.1		
do	91	July 18	3	2 [13]	10.2	58.4	33.4	.2	.3	86	
			27	2 [13]	10.3	58.4		.2	.4	90	
do	79	Aug. 11	3	2, Light smutty [14]	11.0	59.4	33.5	.6	.5	93	Smutty.
			268	2, do [14]	10.9	59.4	33.0	.5	.6	93	
Combine	92	July 17	4	2 [14]	10.3	59.7	34.3	.2	.6	92	Natural.
			118	2 [14]	10.9	59.6	32.2	.2	.3		
Threshed	79	July 18	0	2 [14]	11.1	58.9	33.0	.2	1.6	90	
			117	2 [14]	11.3	58.6	33.0	.2	1.5		
do	91	July 17	1	2 [14]	10.3	59.5	35.0	.1	.6	86	
			118	2 [14]	10.7	59.4	33.0	.1	1.0		
do	85	Aug. 24	7	1 [14]	11.1	60.1	34.5	.2	.7	87	
			80	1 [14]	11.0	60.1	33.9	.1	.6		
do	77	July 22	1	1 [13]	10.7	60.6	33.6	.7	.3	81	
			113	1 [13]	10.7	60.6	33.0	.6	.5		
do	79	July 21	2	2 [6]	10.4	59.6	34.4	.2	.4	86	
			114	2 [6]	10.7	59.4	35.2	.2	.4	92	

MARYLAND [15]

Harvest method or source of wheat	Initial wheat temperature	Date filled	Storage period when sampled	Official grade of sample	Moisture content	Test weight per bushel	Weight per 1,000 kernels	Dockage	Total damaged kernels	Normal germination	Odor
Threshed	78	Aug. 7	5	3, Garlicky	13.9	58.0	38.8	0.8	4.3	87	Natural.
			77	do	13.2	58.1	38.7	.9	4.6	77	
do	78	Aug. 10	2	2, Garlicky	12.9	58.4	37.2	.9	3.6	82	
			86	do	12.9	58.7	37.3	.6	3.8	73	
do	95	July 15	1	2, Garlicky, Tough.	14.3	59.2	39.2	.3	2.1	91	
			71	do	14.4	59.0	39.3	.3	2.3	72	
do	80	July 17	5	4, Garlicky, Smutty, Tough.	15.3	55.6	36.7	1.6	3.2	80	
			110	4, Garlicky, Smutty.	14.0	55.5	36.5	1.5	3.4	82	
do	81	July 20	2	4, Garlicky	12.3	57.2	38.0	1.0	9.7	79	
			56	do	12.3	57.2	38.2	1.0	9.9	81	
do	86	July 17	4	do	12.1	55.0	32.0	5.5	2.5	92	
			69	do	12.0	55.0	32.0	5.9	2.7	86	
do	81	July 22	0	3, Light garlicky.	12.2	57.1	35.6	.1	1.3	89	
			64	do	12.2	56.8	35.7	.1	1.5	96	
do	79	do	0	3, Garlicky, Light smutty.	12.8	57.6	36.0	.9	.2	88	
			64	do	12.6	57.5	36.1	.9	.2	92	

TABLE 42.—*Description of bins and quality of wheat as observed*

BINS IN

Bin No.	County	Location of bin	Roof type	Bin surfaces contacting wheat: Floor: Material	Bin surfaces contacting wheat: Walls: Material	Bin surfaces contacting wheat: Walls: Number exposed to sun	Bulk measurement: Quantity	Bulk measurement: Average depth	Bulk measurement: Half minimum width
							Bu.	*Ft.*	*Ft.*
B-62	Washington	Stock barn	Ceiling	Wood	Wood-lined brick.	2	82	3.5	1.7
B-63	do	do	do	do	Wood	1	920	5.5	5.5
B-64	do	do	do	do	Plaster on brick.	2	100	5.0	3.0
B-65	do	do	do	do	Wood	2	690	4.5	6.0
B-66	do	do	do	do	Wood-lined brick.	2	808	6.0	6.0
B-67-1	do	do	do	do	do	2	170	5.5	2.7
B-67-2	do	do	do	do	do	2	148	5.5	2.5
B-68	do	do	do	do	do	2	1,060	6.0	5.5
B-69	do	do	do	do	Wood	1	165	5.5	2.5
B-70	do	do	do	do	do	1	123	4.0	2.7

[1] All wheat of class Hard Red Spring and subclass Dark Northern Spring.
[2] All walls supporting wheat exposed to sun.
[3] Trace.
[4] All wheat of class Hard Red Winter and subclass Dark Hard Winter except where noted.
[5] Part of wheat removed during storage period; this sample represents remainder only.
[6] Mixed.
[7] Subclass hard winter.
[8] All wheat of class Soft Red Winter and subclass Red Winter except where noted.

from average samples taken in survey of 1936—Continued

MARYLAND[15]—Continued

Harvest method or source of wheat	Initial wheat temperature	Date filled	Storage period when sampled	Official grade of sample	Moisture content	Test weight per bushel	Weight per 1,000 kernels	Dockage	Total damaged kernels	Normal germination	Odor
	°F.		Days		Pct.	Lb.	Gm.	Pct.	Pct.	Pct.	
Threshed	91	July 16	0	4, Garlicky	10.7	54.3	30.0	1.3	0.8	78	Natural.
			70	do	11.1	54.1	30.2	1.4	.9	89	
do	91	do	0	Sample, Garlicky	16.4	55.3	34.5	2.0	1.1	92	
			180	4, Garlicky	13.1	55.0	34.9	2.5	1.2	94	
do	75	July 8	8	2, Garlicky	12.8	58.3	34.4	7	.2	83	
			78	3, Garlicky	12.1	56.7	34.5	1.5	.2	78	
do	89	July 14	2	do	12.6	57.2	38.4	2.2	2.4	86	
			72	do	11.9	57.0	38.2	1.5	2.5	88	
do	80	July 18	3	2	11.0	59.0	32.4	.7	.2	85	
			178	2	11.5	58.9	32.4	.6	.3	85	
do	84	July 15	1	2, Garlicky	12.6	58.7	38.8	.4	.4	88	
			112	do	12.9	58.7	38.8	.4	.5	71	
do	82	do	1	do	11.0	58.5	37.8	.7	1.5	82	
			112	do	11.6	58.8	37.8	.7	1.5	83	
do	86	July 18	4	3, Garlicky	10.8	57.7	32.0	.6	1.0	89	
			68	do	10.9	57.5	32.1	.8	1.0	80	
do	81	July 21	1	2, Garlicky	12.5	58.7	39.6	1.1	1.9	92	
			65	do	12.4	58.5	39.4	1.0	1.9	81	
do	80	July 17	5	do	11.3	59.3	35.6	.6	1.8	84	
			69	do	12.7	59.1	35.5	.7	1.9	89	

[9] Wheat of class Hard Red Winter and subclass Dark Hard Winter.
[10] Wheat of class Hard Red Spring and subclass Northern Spring.
[11] Sample represents heating portion of wheat; no official grade reported.
[12] Wheat of class Hard Red Winter and subclass Hard Winter.
[13] Wheat of class Soft Red Winter and subclass Red Winter.
[14] Wheat of class White and subclass Soft White.
[15] All wheat of class Soft Red Winter and subclass Red Winter.

TABLE 43.—*Description of bins and quality of wheat*

Bin No.	County	Location of bin	Roof type	Bin surfaces contacting wheat: Floor: Material	Bin surfaces contacting wheat: Walls: Material	Bin surfaces contacting wheat: Walls: Number exposed to sun	Bulk measurements: Quantity	Bulk measurements: Average depth	Bulk measurements: Half minimum width
							Bu.	*Ft.*	*Ft.*
BINS IN									
U-76	Champaign	Granary	Ceiling	Wood	Wood	1	400	3.6	4.0
U-85	do	do	Wood shingle	do	do	1	100	5.2	2.4
U-86	do	do	Metal	do	do	1	58	2.2	1.5
U-87	do	do	do	do	do	1	293	6.5	2.8
U-88	do	Stock barn	Ceiling	Concrete	do	1	236	2.6	4.1
U-89	do	Machine shed	Metal	Wood	do	0	80	3.3	1.5
U-90	do	Stock barn	Ceiling	do	do	1	66	3.0	2.4
U-91	do	do	do	Concrete	do	0	120	2.1	4.0
U-92	do	do	do	Wood	do	1	330	4.5	4.0
U-93	do	Granary	do	Metal	Metal	0	78	2.6	2.0
U-94	do	Stock barn	do	Wood	Wood	0	250	2.5	5.0
BINS IN									
T-53	Wood	Outdoors	Wood shingle	Wood	Wood	(6)	340	6.9	3.2
T-59-A	Lucas	Stock barn	do	Concrete	do	1	673	5.5	4.7
T-60	Wood	Granary	Metal	Wood	do	2	107	4.1	2.5
T-61	Fulton	do	Wood shingle	do	do	1	182	4.7	2.7
T-62	do	do	Ceiling	do	do	1	251	6.0	3.3
T-64	do	Stock barn	do	do	do	0	445	5.6	3.9
T-66	do	Granary	do	do	do	2	323	5.7	3.0
T-83	Wood	Stock barn	do	do	do	2	558	4.3	5.8
T-83-B	do	Outdoors	Wood shingle	do	do	(6)	352	5.3	3.7
T-84	do	Granary	do	do	do	1	170	5.2	2.8
T-85	do	do	do	do	do	0	72	2.5	3.0
T-86	do	Stock barn	Ceiling	do	do	1	216	4.8	2.5
T-87	do	Granary	Wood shingle	do	do	1	197	3.8	4.0

See footnotes at end of table.

as observed from average samples taken in survey of 1937

ILLINOIS [1]

Harvest method or source of wheat	Initial wheat temperature	Date filled	Storage period when sampled	Official grade of sample	Moisture content	Test weight per bushel	Weight per 1,000 kernels	Dockage	Total damaged kernels	Normal germination	Fat acidity	Odor
	° F.		*Days*		*Pct.*	*Lb.*	*Gm.*	*Pct.*	*Pct.*	*Pct.*	*Units*	
Combine	78	July 20	15	5, Tough	14.4	53.5	17.2	0.7	0.6	79	18	Natural.
			70	5	14.0	52.5	17.2	.7	.9	81	22	
Threshed	80	July 17	3	3, Tough [2]	14.8	57.0	27.0	.3	.4	94	10	
			31	do [2]	14.8	56.8		.3	.5	93	16	
do	83	July 16	4	Sample	15.7	53.0	21.1	.3	.4	94	20	
			32	do	15.8	52.7		.6	.5	96	21	
do	79	July 17	4	5, Tough	14.8	51.5	19.6	.5	.4	90	25	
			59	do	14.9	51.2		.5	1.2	95	21	
Combine	77	July 19	2	do [3]	15.4	51.3	21.6	.3	.8	92	23	
			64	do [3]	15.5	51.0	21.2	.4	1.5	86	24	
do	77	July 17	6	2, Tough [2]	14.7	58.0	26.5	.2	.3	92	17	
			34	3, Tough [2]	14.8	57.7		.2	.5	93	17	
do	87	do	6	5, Tough	14.7	51.1	20.5	.8	.5	95	20	
			62	do	14.6	51.1		.7	.7	94	21	
do	80	July 20	6	Sample, Tough [3]	15.2	48.4	18.1	.4	.5	90	23	
			63	do [3]	15.2	48.3	17.8	.5	.9	85	22	
do	83	July 17	10	do	14.8	49.6	17.7	.8	.4	73	23	
			16	Sample [4]	16.1	46.4		.8	.8	35	39	Musty.
do	76	July 24	5	Sample, Tough [3]	14.4	50.8	24.3	1.2	.7	82	17	Natural.
			63	do [3]	14.4	50.6	23.5	1.4	.8	87	24	
do	76	July 16	15	do [3]	14.4	37.3	10.5	1.3	1.0	84	29	
			71	do [3]	14.5	37.3	10.8	1.3	1.5	74	29	

OHIO [5]

Threashed	85	July 24	4	5	13.1	53.8	25.8	0.2	2.8	92	16	Natural.
			122	5	13.3	53.6	25.2	.3	2.4	89	19	
Combine	82	July 21	5	4 [2]	13.8	54.0	27.2	.1	1.6	96	17	
			98	5 [2]	13.9	53.3	28.8	.3	1.2	93	17	
do	79	do	7	5 [2]	13.5	53.8	26.2	.1	.9	96	17	
			65	5 [2]	13.3	53.5	29.6	.2	1.6	94	22	
Threshed	77	July 23	10	5	13.1	52.7	25.0	.3	3.2	87	19	
			41	5	13.0	52.4	24.0	.3	4.2	88	19	
do	81	July 24	9	4 [2]	13.0	55.6	24.2	.2	.9	90	20	
			95	4 [2]	13.0	55.4	24.0	.3	1.0	90	19	
do	82	do	2	3	13.4	57.7	33.7	.0	.6	95	21	
			61	3	13.3	57.2	35.0	.1	.6	92	20	
do	83	Aug. 3	7	5, Tough, Smutty	14.2	52.5	25.0	.4	10.0	89	13	
			85	Sample, Tough, Smutty.	14.4	52.6	26.4	.5	16.2	69	27	
do	88	July 23	5	3 [2]	12.6	56.4	27.8	.1	1.7	91	18	
			63	3 [2]	12.7	55.7		.1	1.5	87	20	
do	80	July 29	1	Sample [7]	13.3	47.5	17.0	.4	2.8	85	19	
			117	do [7]	13.7	47.5	17.6	.3	4.3	83	25	
do	71	July 21	7	3 [2]	13.8	56.8	26.9	.1	.7	96	22	
			44	3 [2]	13.8	56.8		.1	.5	94	21	
Combine	89	July 23	5	Sample [7]	11.4	50.4	22.9	.3	4.6	92	13	
			53	do [7]	11.8	50.5	22.9	.3	5.0	91	20	
Threshed	76	July 24	6	5	12.3	51.7	23.0	.1	10.0	87	23	
			122	5	12.4	51.5	23.8	.4	8.6	88	19	
Combine	86	do	6	Sample [7]	12.8	50.8	26.8	.2	9.5	89	24	
			122	do [7]	13.0	50.5	26.2	.2	11.0	83	19	

TABLE 43.—*Description of bins and quality of wheat as*

Bin No.	County	Location of bin	Roof type	Bin surfaces contacting wheat: Floor: Material	Bin surfaces contacting wheat: Walls: Material	Bin surfaces contacting wheat: Walls: Number exposed to sun	Bulk measurements: Quantity	Bulk measurements: Average depth	Bulk measurements: Half minimum width
BINS IN									
							Bu.	*Ft.*	*Ft.*
T-70-A	Monroe	Granary	Wood shingle	Concrete	Wood	2	251	2.9	4.8
T-70-B	do	do	do	do	do	2	159	2.9	2.9
T-71-A	do	do	Ceiling	Wood	do	1	166	3.8	3.8
T-72	do	Stock barn	Shingle asbestos.	Concrete	do	1	416	2.8	5.1
T-74-A	do	Granary	Ceiling	Wood	do	1	155	2.8	3.8
T-74-B	do	do	do	do	do	2	139	2.2	3.8
T-75	do	do	do	do	do	2	222	5.8	3.0
T-78	Lenawee	do	do	do	do	2	216	5.8	2.0
T-79	do	do	Wood shingle	Concrete	do	3	410	5.3	3.8
T-80-A	do	do	Ceiling	Wood	do	0	551	6.3	3.5
T-81	do	House	Plastered	do	Plastered	3	773	5.0	6.9
T-82-A	do	Stock barn	Ceiling	Concrete	Wood	1	658	5.2	6.0
T-88	do	Granary	do	Wood	do	2	313	6.0	2.1
BINS IN									
B-50	Washington	Stock barn	Ceiling	Wood	Wood	2	900	4.0	5.5
B-51	do	do	do	do	do	2	1,100	4.0	5.5
B-52	do	do	do	do	do	2	147	3.3	3.2
B-53	do	do	do	do	Wood-lined brick.	2	907	7.0	6.0
B-54	do	do	do	do	do	2	550	5.5	3.5
B-55	do	do	do	do	do	2	392	4.6	3.5
B-56	do	do	do	do	Wood	2	637	4.1	5.0
B-57	do	do	do	do	do	2	358	5.3	3.5
B-58	do	do	do	do	do	2	288	2.5	6.0
B-59	do	do	do	do	do	2	432	2.5	6.0
B-60	do	do	do	do	do	2	90	2.1	3.0
B-61	do	do	do	do	do	1	86	2.0	3.0

[1] All wheat of class Hard Red Winter and subclass Hard Winter except where noted.
[2] Wheat of class Soft Red Winter and subclass Red Winter.
[3] Wheat of class Hard Red Winter and subclass Yellow Hard Winter.
[4] Sample representing inferior portion of bin.

observed from average samples taken in survey of 1937—Continued

ILLINOIS [1]

Harvest method or source of wheat	Initial wheat temperature	Date filled	Storage period when sampled	Official grade of sample	Moisture content	Test weight per bushel	Weight per 1,000 kernels	Dockage	Total damaged kernels	Normal germination	Fat acidity	Odor
	° F		*Days*		*Pct.*	*Lb.*	*Gm.*	*Pct.*	*Pct.*	*Pct.*	*Units*	
Threshed	85	Aug. 24	7	Sample, Tough	14.7	46.3		1.7	52.0	52	29	Sour.
			127	do	15.3	45.0	22.7	1.8	87.5	1	69	Musty.
do	80	do	7	do	14.7	46.3	24.5	1.7	51.0	48	32	
			127	do	14.8	46.0	21.5	1.7	71.0	2	68	Sour.
do	89	Aug. 20	6	do	15.2	48.7	29.1	.7	44.0	58	24	
			26	Sample	15.7	46.3		.9	72.5	12	43	
do	88	Aug. 3	7	4	12.8	55.3	29.0	.2	8.3	85	14	
			85	5	13.1	55.1	30.4	.2	15.5	85	17	Natural.
do	82	Aug. 14	12	Sample	16.0	53.5	30.0	.3	14.2	81	22	
			32	do	16.1	51.5		.5	16.0	58	34	Musty.
do	78	do	12	do	15.6	52.2	29.6	.6	12.6	79	23	Natural.
			32	do	15.6	51.0		.5	16.6	66	26	Musty.
do	87	Aug. 16	15	5	13.5	55.4	29.6	.2	11.0	83	17	
			135	4	13.3	54.5		.2	10.0	82	16	
do	85	July 30	3	5 [2]	13.4	54.8	29.0	2.6	1.2	84	22	
			152	4 [2]	13.2	54.8	29.2	1.9	2.0	83	19	
Combine	83	July 27	6	Sample [2]	13.7	50.3	21.8	.2	.5	96	19	
			92	Sample [2]	14.0	50.2	21.6	.2	.7	87	20	
Threshed	81	Aug. 18	15	5	13.7	53.1	27.6	.8	14.5	83	21	Natural.
			23	5	14.0	52.8		.9	14.2	84	20	
do	83	Aug. 3	7	4	13.5	54.5	27.8	.5	2.0	81	12	
			148	4	13.5	54.2	27.5	.3	3.5	81	18	
do	82	July 21	0	4 [2]	14.4	55.1	27.2	.4	.6	93	14	
			64	3 [2]	14.2	56.0	29.1	.4	.9	92	19	
do	79	July 26	7	Sample	15.8	49.8	25.8	.5	12.0	76	25	
			15	do	18.2	46.6	25.0	.5	100.0	1	34	Sour.

MARYLAND [3]

Harvest method or source of wheat	Initial wheat temperature	Date filled	Storage period when sampled	Official grade of sample	Moisture content	Test weight per bushel	Weight per 1,000 kernels	Dockage	Total damaged kernels	Normal germination	Fat acidity	Odor
Threshed	77	July 21	12	3, Garlicky, Tough	15.1	57.3	33.2	.4	1.9	89	12	Natural.
			63	Sample, Garlicky [4]	15.8	54.0			3.1	8	35	Sour.
do	81	July 22	11	4, Garlicky, Tough	14.2	54.6	30.8	1.1	6.5	83	24	
			40	do	14.2	54.6			6.4	78	22	
do	77	July 28	5	do	15.3	58.4	35.3	.7	1.8	90	12	
			90	do	15.4	58.2			1.9	80	21	
do	76	July 30	3	3, Garlicky	13.9	57.3	34.8	1.6	4.8	87	10	
			293	do	13.2	57.3	38.6	1.8	5.0	82	21	
do	85	July 28	5	3, Garlicky, Tough	14.7	57.2	34.8	1.2	3.8	83	17	
			295	3, Garlicky	14.0	57.0	35.6	1.2	3.7	80	26	
do	87	do	5	4, Garlicky	14.0	56.5	32.4	.7	7.8	80	25	
			295	do	13.8	56.3	34.0	.8	8.0	72	26	
do	76	do	5	3, Garlicky	13.7	57.0	33.5	.7	3.2	85	11	
			34	do	13.7	57.0	33.7	.8	3.3	90	16	Natural.
do	83	July 29	4	do	13.7	56.4	32.6	.4	3.4	86	10	
			33	do	13.6	56.4	32.5	.4	3.4	90	20	
do	80	July 30	10	3, Garlicky, Tough	14.3	56.7	31.9	1.9	3.9	90	14	
			46	3, Garlicky	14.0	56.8			3.8	91	18	
do	81	do	10	1, Garlicky	14.0	60.0	36.9	1.3	1.4	92	15	
			40	do	14.0	60.1	36.7	1.4	1.3	93	19	
do	81	July 13	27	2, Garlicky, Tough Smutty.	15.1	58.8	33.7	1.2	2.8	87	20	
			49	do	15.0	58.7			2.8	88	23	
do	78	do	27	do	15.1	59.8	37.2	.6	.8	91	18	
			71	do	14.9	59.7	36.9	.5	.9	81	21	

[5] All wheat of class White and subclass Soft White except where noted.
[6] All walls supporting wheat exposed to sun.
[7] Mixed.

TABLE 44.—*Wheat grade data and bin descriptions*

WHEAT FROM 1939

Bin No.	County	Location of Bin	Roof type	Bin surfaces contacting wheat: Floor: Material	Bin surfaces contacting wheat: Walls: Material	Bin surfaces contacting wheat: Walls: Number exposed to sun	Bulk measurements: Quantity	Bulk measurements: Average depth	Bulk measurements: Half minimum width
							Bu.	*Ft.*	*Ft.*
K-12	Sedgwick	Granary	Wood shingle	Concrete	Wood	2	1,110	8.2	6.0
K-13	do	do	do	do	do	2	674	7.0	5.0
K-14	do	do	do	Wood	do	2	273	5.2	4.0
K-15	do	Outdoors	Metal	Metal	Metal	3	1,110	9.0	7.0
K-18	Sumner	do	Boxcar	Wood	Wood	3	990	4.3	4.0
K-19	do	do	do	do	do	(6)	1,430	6.2	4.0
K-20	do	Tool shed	Metal	do	do	2	4,000	9.3	4.5
K-22	do	Outdoors	Boxcar	do	do	(6)	1,380	6.0	4.0
K-23	do	do	Wood shingle	do	do	2	678	6.0	4.0
K-24	do	do	Metal	Metal	Metal	(6)	636	4.5	7.5
K-25	do	Granary	Wood shingle	Wood	Wood	2	1,808	4.7	10.0
K-28	Sedgwick	do	Ceiling	do	do	2	1,570	8.5	5.2
K-29	do	do	do	do	do	2	690	4.3	6.0
K-31 [10]	do	do	Metal	do	Wood-lined metal.	3	570	6.5	4.5
K-34	do	do	Wood shingle	do	Wood	3	1,570	5.0	7.0
K-35	do	do	do	do	do	3	50	----	----
K-36	Pratt	Outdoors	Metal	Metal	Metal	(6)	1,150	11.0	7.0
K-37	do	do	do	do	do	(6)	905	10.0	6.0
K-39	do	Stock barn	Ceiling	Wood	Wood	1	825	--	--
K-40	do	do	do	do	do	1	800	----	----
K-44 [11]	Sedgwick	Ourdoors [1]	Metal	Metal	Metal	(6)	376	3.0	7.0
K-45	do	do	do	do	do	(6)	495	4.0	7.0
K-1	Riley	Stock barn	Ceiling	Wood	Wood	0	281	4.0	4.0
K-2	do	Outdoors	Boxcar	do	do	(6)	3,960	9.8	6.8
K-3	do	Granary	Wood shingle	do	do	2	1,152	6.0	6.0
K-4	do	Elevator	Ceiling	do	do	2	584	7.6	4.9
K-5	do	Open shed	Boxcar	do	do	3	2,030	5.0	6.7
K-6	do	Outdoors	do	do	do	(6)	2,238	5.5	6.7
K-7	Franklin	do	Metal	Metal	Metal	(6)	416	7.6	4.6
K-8	do	do	Boxcar	Wood	Wood	(6)	506	4.2	4.0
K-9	do	do	Metal	Metal	Metal	(6)	506	4.1	7.0
K-10	do	Granary		Wood	Wood	2	436	4.2	4.0
K-11	do	Outdoors	Boxcar	do	do	(6)	151	3.0	3.5
K-16	Sedgwick	do	Metal	Metal	Metal	3	1,000	8.0	7.0
K-17	Sumner	do	Boxcar	Wood	Wood	(6)	986	5.5	4.0
K-21	do	do	Metal	Metal	Metal	(6)	840	6.8	7.0
K-26	do	Granary	Wood shingle	Wood	Wood	3	50	--	--
K-30	Sedgwick	Outdoors	Metal	Metal	Metal	(6)	985	8.0	7.0
K-32 [10]	do	Stock barn	Floor	Wood	Wood	2	415	4.8	3.8
K-33 [10]	do	Outdoors	Metal	Metal	Metal	(6)	836	7.2	6.7
K-38	Pratt	do	do	do	do	(6)	860	7.0	7.0
K-41	do	Stock barn	Floor	Wood	Wood	1	800	--	--
K-42	do	Granary		do	do	2	418	4.0	5.4
K-43	do	Outdoors	Metal	Metal	Metal	(6)	680	5.5	7.0
K-46	Sedgwick	do	do	do	do	(6)	990	8.0	7.0
K-47	do	do	do	do	do	(6)	635	7.0	6.0
K-48	do	Granary		Wood	Wood	2	300	--	--

[1] All wheat of class Hard Red Winter and subclass Hard Winter except where noted.
[2] Wheat of class Hard Red Winter and subclass Yellow Hard Winter.
[3] Commercially objectionable foreign odor—treated with gasoline.
[4] Trace.
[5] Layers of Tough wheat heating and turning sour.
[6] All walls supporting wheat exposed to sun.

for all bins sampled in 1939 farm survey in Kansas

STORED IN KANSAS

Harvest method or source of wheat	Average temperature when sampled	Storage period when sampled	Portion of bulk sampled	Official grade of sample [1]	Moisture content	Test weight per bushel	Weight per 1,000 kernels	Dockage	Total damaged kernels	Normal germination	Fat acidity	Odor
	°F.	Days			Pct.	Lb.	Gm.	Pct.	Pct.	Pct.	Units	
Combine	[1] 88	20	Average	3 [2]	13.4	56.1	----	.0	3.2	96	11	Natural.
		86	Remainder	Sample	12.6	56.1	26.0	.1	1.0	94	13	COFO.[3]
do	90	23	Average	2	11.1	58.7	----	.0	.9	98	14	Natural.
		89	do	2	10.6	58.9	29.0	.2	(4)	98	11	Do.
do	90	27	Average	1	11.6	60.1	----	.0	.5	82	13	Natural.
		93	Remainder	1	10.2	60.3	26.2	.2	.3	90	11	Do.
do	104	26	Average	3 [2]	13.6	57.5	----	.0	1.2	68	13	Natural.[5]
		92	Remainder	Sample	12.6	57.0	29.6	.4	25.0	3	23	Sour.
do	91	27	Average	2	10.8	59.4	----	.0	1.0	88	13	Natural.
		94	do	2	10.5	59.7	20.5	.2	.5	85	12	Do.
Threshed	94	23	do	4 [2]	11.1	56.1	----	.0	8.2	95	9	Do.
		90	do	3	11.3	57.2	30.0	.2	6.0	45	16	Do.
Combine	92	32	do	1 [7]	10.6	62.6	----	.0	.2	94	8	Do.
		96	do	1 [7]	10.2	62.7	33.0	.2	(4)	94	8	Do.
do	95	26	do	3	10.7	56.3	----	.0	.3	87	12	Do.
		90	do	3	10.3	56.0	27.0	.5	(4)	95	13	Do.
do	91	21	do	2, Tough	14.3	58.4	----	.0	1.0	88	14	Do.
		85	do	4	13.6	58.3	30.0	.4	10.0	58	21	Do.[8]
do	93	28	do	3	13.2	57.8	----	.0	.8	97	13	Do.[9]
		92	Remainder	Sample	13.9	58.0	29.0	.2	1.7	75	16	Sour.
do	91	28	Average	2	12.7	58.5	----	.0	.8	98	13	Natural.
		92	do	2	12.1	59.7	29.0	.2	.1	93	12	Do.
do	94	23	do	1	13.3	60.0	----	.0	.9	93	9	Do.
		88	do	Sample	13.0	60.2	31.0	----	4.0	76	16	Sour.
do	93	28	do	2, Tough	14.2	58.7	----	.0	1.1	91	14	Natural.
		93	do	Sample	14.0	58.1	29.0	.3	10.0	27	32	Sour.
do	91	21	do	3	13.5	57.2	----	.0	.9	93	14	Natural.
		86	do	3	11.8	57.6	24.5	.2	.5	90	16	Do.
		26	do	2	12.7	59.2	----	.0	1.4	97	11	Do.
do	86	91	do	2	10.9	58.5	29.0	.4	.4	97	14	Do.
do	97	30	do	Sample	17.3	54.0	----	.0	16.0	68	24	Musty.
		30+65	do	3	12.2	57.6	28.0	.4	2.0	72	21	Natural.
do	93	34	do	3 [2]	11.0	56.7	----	.0	.8	97	9	Do.
		100	do	3	10.8	56.0	26.0	.2	(4)	99	10	Do.
do	87	32	do	3	12.1	57.2	----	.0	.7	98	9	Do.
		98	do	3 [7]	11.3	57.8	22.0	.3	(4)	98	11	Do.
do	91	10+10+12	do	1 [7]	12.9	61.3	----	.0	.3	92	11	Do.
		10+10+78	do	2 [7]	13.0	59.2	31.5	.2	.5	51	15	Do.
do	84	8+10+12	do	1, Tough [7]	14.7	60.3	----	.0	.4	85	8	Do.
		8+10+78	do	do [6]	14.2	61.4	33.0	.4	(4)	77	15	Do.
do	89	10+27	do	2	10.4	59.8	----	.0	1.0	94	11	Do.
		10+91	do	2	10.3	59.7	32.0	.2	(4)	93	10	Do.
do	87	29	do	4 [2]	11.0	56.8	----	.0	.7	97	9	Do.
		93	do	2	11.7	58.4	28.0	.2	2.0	74	15	Do.
Threshed	84	13	do	5	14.0	52.7	----	1.0	3.0	91	17	Do.
Combine	95	11	do	2	11.6	58.2	----	.0	1.3	94	13	Do.
do	----	2	do	3 [2]	11.6	57.1	----	.0	3.0	90	12	Do.
do	86	2	do	2 [2]	11.0	59.4	----	.0	2.0	91	11	Do.
do	85	6	do	3 [2]	11.1	57.1	----	.0	1.0	95	13	Do.
do	83	6	do	3 [2]	12.0	57.8	----	.0	.5	----	----	Do.
do	97	10	do	4	13.0	55.8	----	.0	.9	94	12	Do.
do	97	13	do	4, Touth [2]	14.8	55.2	----	.0	2.0	92	12	Do.
Threshed	97	10	do	3, Tough [2]	14.3	57.1	----	.0	2.0	95	13	Do.
Combine	95	12	do	2 [2]	11.2	59.1	----	.0	2.6	78	9	Do.
do	93	11	do	3	13.9	59.4	----	.0	4.5	89	8	Do.
do	90	23	do	2 [2]	11.7	59.1	----	.0	2.3	81	12	Do.
do	86	23	do	3 [2]	12.4	57.1	----	.0	2.0	90	12	Do.
do	95	19	do	3 [2]	11.4	56.1	----	.0	.4	81	14	Do.
do	94	30	Inferior	Sample, Tough	14.1	55.7	----	.0	4.4	----	----	Musty.
do	84	30	Average	2	11.8	58.8	----	.0	1.0	91	13	Natural.
do	103	21	do	Sample, Tough	15.3	56.0	----	.0	1.6	80	16	Musty.
do	97	17	do	2 [2]	12.2	58.2	----	.0	1.3	96	10	Natural.
do	93	28	do	2	11.4	58.2	----	.0	.6	88	12	Do.
do	92	26	do	5	13.1	56.9	----	----	.6	77	12	Do.
do	90	34	do	3	10.9	56.0	----	.0	.4	----	----	Do.
do	92	34	do	2 [7]	9.7	59.1	----	.0	.3	95	11	Do.
do	90	15	do	1 [7]	11.3	60.5	----	.0	.3	90	9	Do.
do	107	41	do	Sample	13.9	57.4	----	.0	1.2	91	10	Musty.
do	92	37	do	2	11.8	58.6	----	.0	.3	91	8	Natural.

[7] Wheat of class Hard Red Winter and subclass Dark Hard Winter.

[8] Musty layers on bottom of lot.

[9] Layers of damp wheat on bottom of lot.

[10] Soda at rate of 1 pound to 50 bushels of wheat added to wheat when bin was filled.

[11] Began heating in another bin, was then run through combine, treated for weevil and stored in this bin

TABLE 45.—*Wheat grade data and bin descriptions for all bins sampled in survey 1936, 1937, and*

Bin No.	County	Location of bin	Roof type	Bin surfaces contacting wheat: Floor: Material	Bin surfaces contacting wheat: Walls: Material	Bin surfaces contacting wheat: Walls: Number exposed to sun	Bulk measurements: Quantity	Bulk measurements: Average depth	Bulk measurements: Half minimum width
							Bu.	*Ft.*	*Ft.*
WHEAT FROM 1936 CROP									
S-107	Lorain	Granary	Wood shingle	Wood	Wood	3	160	2.0	4.0
WHEAT FROM 1937 CROP									
S-2	Fairfield	Granary	Wood shingle	Wood	Wood	None	150	3.0	2.0
S-20	Henry	Stock barn	Ceiling	do	do	None	200	5.0	2.0
S-29A	do	Granary	do	do	do	1	360	3.5	5.0
S-78	Ashland	Stock barn	do	do	do	2	150	3.0	2.5
S-82	do	do	do	do	do	2	200	3.7	2.7
S-100	Lorain	Granary	do	do	do	None	100	2.0	2.0
S-101	do	do	do	do	do	None	100	4.0	2.0
S-102	do	do	do	do	do	None	100	2.0	2.5
S-105	do	do	do	do	do	1	300	3.0	4.0
WHEAT FROM 1937 CROP									
S-110	Clinton	Granary	Ceiling	Wood	Wood	3	200	5.0	4.0
S-111	do	do	do	do	do	2	200	6.0	4.0
S-116	do	do	Wood shingle	do	do	1	200	3.0	2.5
WHEAT FROM 1938 CROP									
S-1	Highland	Granary	Metal	Wood	Wood	2	543	4.6	4.8
S-3	do	House	Plaster	do	Plaster	None	454	1.5	4.6
S-4	Fairfield	Granary	Ceiling	do	Wood	None	177	2.1	4.7
S-5	do	do	Metal	do	do	None	546	3.0	3.6
S-6	Henry	do	Wood shingle	do	do	None	139	6.6	2.2
S-7	do	do	Ceiling	do	do	None	298	3.0	5.1
S-8	do	do	Metal	do	do	None	490	5.6	2.7
S-9	do	Stock barn	Ceiling	do	do	None	358	6.0	4.1
S-10	do	Granary	Wood shingle	do	do	2	433	5.5	4.0
S-11	do	do	Metal	do	do	1	470	6.6	4.0
S-12	do	do	do	do	do	2	122	3.0	2.1
S-13	do	do	do	do	do	2	275	5.6	3.0
S-14	do	do	Wood shingle	do	do	2	265	6.3	2.7
S-15	do	do	Cement shingle.	do	do	1	193	3.5	3.0
S-16	do	Stock barn	Ceiling	do	do	None	165	5.1	2.9
S-17	do	Granary	Wood shingle	do	do	1	145	6.0	2.7
S-18	do	Stock barn	Ceiling	do	do	None	264	5.5	3.7
S-19	do	Granary	Metal	do	do	None	486	3.5	6.1
S-21A	do	Stock barn	Wood shingle	Concrete	do	None	1,496	6.3	5.7
S-21B	do	do	do	do	do	None	1,496	6.3	5.7
S-22	do	do	Ceiling	Wood	do	None	119	4.1	2.3
S-23	do	Granary	Metal	do	do	None	159	4.0	2.5
S-24	do	do	do	do	do	None	385	3.6	5.5
S-25	do	do	do	do	do	None	304	6.3	3.0
S-26	do	Stock barn	Ceiling	do	do	None	97	2.7	1.7
S-27	do	do	do	do	do	None	347	4.0	3.5
S-28	do	Granary	Metal	do	do	None	248	6.6	3.3
S-29	do	do	Ceiling	do	do	None	192	2.0	5.5
S-30	do	do	Wood shingle	do	do	None	450	2.2	7.3
S-31	do	do	do	do	do	None	748	3.3	4.0
S-32	do	do	do	do	do	None	299	3.0	3.5
S-33	do	Stock barn	Ceiling	do	do	None	574	3.5	6.2
S-34	do	Granary	Wood shingle	do	do	None	403	7.0	3.0
S-35	do	Stock barn	Ceiling	do	do	2	712	5.0	5.5
S-36	do	Granary	Slate shingle	do	do	None	179	2.3	4.3
S-37	Wood	do	Wood shingle	do	do	3	418	8.0	2.5
S-38	do	Stock barn	Ceiling	do	do	1	212	3.6	2.

See footnotes at end of table.

of 1939 of wheat stored under loan in Ohio, Michigan, and Indiana. Wheat of 1938 crops included

STORED IN OHIO

Harvest method or source of wheat	Storage period when sampled	Portion of bulk sampled	Official grade of sample [1]	Moisture content	Test weight per bushel	Dockage	Total damaged kernels	Normal germination	Fat acidity	Odor
	Days			*Pct.*	*Lb.*	*Pct.*	*Pct.*	*Pct.*	*Units*	
Threshed	1,034	Average	Sample, Tough	14.5	53.7	0.4	10.0	36	30	Musty.

STORED IN OHIO

Threshed	669	Remainder	4, Tough	14.9	54.0	0.5	10.0	44	29	Natural.
do	662	do	Sample, Tough	14.2	54.4	.4	15+	0	49	Sour.
Combine	662	do	do	13.3	53.1	.1	15+	31	37	Musty.
Threshed	665	Average	do	14.3	56.8	.2	12.5	69	27	Do.
do	665	do	3	13.8	57.4	.4	5.2	25	34	Natural.
do	666	do	4, Tough	14.6	55.4	.6	3.0	82	23	Do.
do	668	do	3	13.9	56.8	.7	1.5	82	27	Do.
do	668	do	3	14.0	56.0	.2	5.8	93	28	Do.
do	668	do	Sample	13.5	55.7	.5	4.0	82	25	Sour.

STORED IN MICHIGAN

Threshed	671	Average	3 [2]	13.3	56.1	0.3	3.0	77	24	Natural.
do	671	do	Sample, Tough [2]	14.8	58.4		12.0	35	41	Musty.
do	672	Remainder	4, Tough [2]	14.4	54.6	.9	3.0	71	24	Natural.

STORED IN OHIO

Threshed	300	Average	3	13.4	57.2	0.2	7.0	44	27	Natural.
do	300	do	3	13.0	56.6	.3	2.0	68	21	Do.
do	300	do	3	13.3	58.8	.3	4.5	83	21	Do.
do	300	do	2	13.1	58.4	.4	4.0	81	24	Do.
do	300	do	3, Tough	14.2	60.0	.2	6.0	87	24	Do.
do	300	do	2	13.7	59.4	.3	1.0	75	23	Do.
do	300	do	1	13.9	60.6	.2	2.0	88	22	Do.
do	300	do	1	13.6	60.2	.1	1.0	87	19	Do.
do	300	do	2	13.5	59.3	.3	2.8	85	22	Do.
do	300	do	1	13.1	61.6	.2	1.5	82	19	Do.
do	300	do	3	13.5	60.4	2.3	5.4	82	25	Do.
do	300	do	2	13.4	60.6	.2	2.8	91	19	Do.
do	300	do	2	13.9	59.4	1.4	2.0	87	26	Do.
do	300	do	2	13.5	59.7	.2	.9	90	21	Do.
do	300	do	2, Tough	14.2	59.8	.1	2.0	93	19	Do.
do	300	do	1	13.4	61.7	.1	2.0	90	18	Do.
do	300	do	2	13.1	59.8	.3	1.0	89	25	Do.
do	300	do	3 [3]	13.5	57.0	.5	3.0	84	22	Do.
Combine	300	South half	4 [3]	13.7	55.5	.7	2.5	93	22	Do.
do	300	North half	4 [3]	13.3	55.5	.5	1.5	91	25	Do.
Threshed	300	Average	1	13.6	60.5	1.8	2.0	95	22	Do.
do	300	do	2, Tough	14.2	60.4	1.6	3.5	76	23	Do.
Combine	300	do	1	13.6	60.4	.9	1.5	91	19	Do.
Threshed	300	do	3	13.8	59.0	1.2	7.0	77	19	Do.
do	300	do	3, Tough	14.2	57.0	1.8	6.0	77	22	Do.
do	300	do	1	13.3	61.3	.3	0	75	25	Do.
do	300	do	1	14.0	60.6	.4	2.0	79	21	Do.
do	300	do	2, Tough	14.5	59.3	.2	1.7	79	21	Do.
do	300	do	2	12.7	60.7	.2	2.6	91	17	Do.
do	300	do	1	13.5	61.7	.2	1.8	82	21	Do.
do	300	do	3, Tough	14.7	59.0	.1	5.5	77	24	Do.
do	300	do	1	13.8	61.0	.1	1.0	85	22	Do.
do	300	do	2, Smutty	13.7	58.6	.2	.9	84	23	Smutty.
do	300	do	2 [2]	13.8	60.0	.2	3.0	82	27	Natural.
do	300	do	4, Tough	14.9	56.4	3.9	9.0	76	25	Do.
do	300	do	2	13.2	59.2	.3	2.5	81	23	Do.
do	300	do	2	13.4	59.0	.2	1.5	80	23	Do.[4]

TABLE 45.—*Wheat grade data and bin descriptions for all bins sampled in survey 1936, 1937, and 1938 crops*

WHEAT FROM 1938 CROP

Bin No.	County	Location of bin	Roof type	Bin surfaces contacting wheat: Floor: Material	Bin surfaces contacting wheat: Walls: Material	Bin surfaces contacting wheat: Walls: Number exposed to sun	Bulk measurements: Quantity	Bulk measurements: Average depth	Bulk measurements: Half minimum width
							Bu.	*Ft.*	*Ft.*
S-39	Wood	Granary	Wood shingle	Wood	Wood	None	164	5.5	3.2
S-40	do	do	do	do	do	None	147	5.0	3.2
S-41	do	Stock barn	Ceiling	do	do	None	164	6.5	2.5
S-42	do	do	do	do	do	None	152	6.0	2.5
S-43	do	Granary	Wood shingle	do	do	None	405	4.7	3.8
S-44	do	Stock barn	Ceiling	do	do	None	160	4.3	2.7
S-45	do	Granary	Wood shingle	do	do	2	476	3.5	6.0
S-46	do	do	Metal	do	do	2	370	6.5	3.0
S-47	do	Stock barn	Ceiling	do	do	None	509	7.5	4.5
S-48	do	Tool house	Wood shingle	do	do	None	220	7.7	2.6
S-49	do	Stock barn	Ceiling	do	do	None	100	5.1	2.1
S-50	do	Granary	Wood shingle	do	do	2	244	4.6	4.0
S-51	Crawford	do	Metal	do	Paper-lined wood.	1	62	2.3	2.5
S-52	do	Stock barn	Ceiling	do	Wood	None	121	4.0	2.3
S-53	do	do	Metal	do	do	None	261	4.9	3.7
S-54	do	do	Ceiling	do	do	None	169	6.5	2.0
S-55	do	do	do	do	do	None	168	6.5	2.0
S-56	do	do	do	do	do	None	250	2.9	3.8
S-57	do	do	do	do	do	None	189	6.2	2.5
S-58	do	do	do	do	do	None	197	6.2	2.6
S-59	do	do	do	do	do	None	113	4.9	2.2
S-60	do	do	do	do	do	None	104	6.6	2.0
S-61	do	do	do	do	do	None	96	6.6	2.0
S-62	do	do	do	do	do	None	131	6.9	2.0
S-63	do	Tool house	Metal	do	do	None	100	3.0	3.0
S-64	do	Stock barn	do	do	do	None	285	1.5	7.7
S-65	do	do	do	do	do	None	207	1.7	3.9
S-66	Ashland	do	Ceiling	do	do	None	243	3.2	4.0
S-67	do	do	do	do	do	None	505	6.0	3.8
S-68	do	do	do	do	do	None	180	2.9	3.8
S-69	do	do	do	do	do	None	183	4.7	2.7
S-70	do	do	do	do	do	None	247	3.9	4.4
S-71	do	do	do	do	do	None	145	4.5	2.2
S-72	do	do	do	do	do	None	156	6.2	2.0
S-73	do	do	do	do	do	None	301	3.9	3.3
S-74	do	do	do	do	do	None	227	4.9	3.7
S-75	do	do	do	do	do	None	221	5.1	2.5
S-76	do	do	do	do	do	None	167	3.0	2.5
S-77	do	do	do	Metal-lined wood.	do	None	334	8.3	2.5
S-79	do	Hen house	do	Concrete	do	None	178	3.0	3.8
S-80	do	do	do	do	do	None	320	5.0	3.9
S-81	do	Stock barn	do	Wood	do	None	184	5.6	2.7
S-83	Wayne	Granary	Metal	do	do	None	337	5.3	3.7
S-84	do	Stock barn	Ceiling	do	do	None	133	6.3	1.8
S-85	do	do	do	do	do	None	134	3.5	3.2
S-86	do	do	do	do	do	None	464	4.2	5.6
S-87	do	do	do	do	do	None	96	5.5	2.5
S-88	do	do	do	do	do	None	118	5.5	2.5
S-89	do	do	do	do	do	None	258	6.0	2.8
S-90	do	do	do	do	do	None	130	4.0	2.1
S-91	do	do	do	do	do	None	100	4.0	3.1
S-92	do	do	do	do	do	None	108	2.1	3.5
S-93	do	do	do	do	do	None	216	4.5	3.4
S-94	do	do	do	do	do	None	129	4.6	3.0
S-95	do	do	do	do	do	None	198	6.0	2.9
S-96	do	do	do	do	do	None	142	5.5	2.5
S-97	do	do	do	do	do	None	194	6.1	2.9
S-98	do	do	do	do	do	None	309	5.0	3.3
S-99	Lorain	Granary	Asphalt shingle.	do	do	None	511	5.5	3.8
S-103	do	do	Metal	do	do	1	164	11.0	1.8
S-104	do	Stock barn	Ceiling	do	do	None	170	5.0	2.8
S-106	do	Tool house	Asphalt shingle.	do	do	None	415	1.2	9.8

of 1939 of wheat stored under loan in Ohio, Michigan, and Indiana. Wheat of included—Continued

STORED IN OHIO—Continued

Harvest method or source of wheat	Storage period when sampled	Portion of bulk sampled	Official grade of sample [1]	Moisture content	Test weight per bushel	Dockage	Total damaged kernels	Normal germination	Fat acidity	Odor
	Days			*Pct.*	*Lb.*	*Pct.*	*Pct.*	*Pct.*	*Units*	
Threshed	300	Average	2	13.3	61.0	.2	2.5	90	22	Natural.
do	300	do	1	13.3	61.0	.2	.9	96	22	Do.
do	300	do	1	12.8	60.7	1.3	2.0	74	20	Do.
do	300	do	1	13.5	60.5	1.7	.9	76	22	Do.
do	300	do	1	12.6	61.4	.5	1.4	85	20	Do.
do	300	do	2	13.2	59.2	.2	2.2	86	27	Do.
Combine	300	do	1	14.0	60.5	.3	1.5	94	24	Do.
Threshed	300	do	1	13.9	61.0	.1	.5	95	22	Do.
do	300	do	3, Tough [3]	14.4	57.7	1.8	6.5	64	29	Do.
do	300	do	1, Tough	14.6	60.8	.2	1.4	79	26	Do.
Combine	300	do	Sample, Tough	14.9	60.0	.2	3.0	48	29	COFO.[5]
Threshed	300	do	2, Tough, Smutty	14.2	58.6	.8	3.0	69	28	Smutty.
Combine	300	do	2, Tough	15.1	59.0	.3	3.5	74	26	Natural.
Threshed	300	do	1	12.6	60.3	1.0	1.3	94	22	Do.
do	300	do	4	14.0	60.4	.2	2.5	86	23	Do.
do	300	do	2, Tough	14.1	59.7	.2	2.0	91	23	Do.
do	300	do	2	13.7	59.7	.3	1.0	88	24	Do.
do	300	do	1, Tough	14.7	60.8	.3	1.0	94	20	Do.
do	300	do	1	14.0	60.7	.4	.8	93	19	Do.
do	300	do	2, Tough	14.2	60.5	.5	3.7	96	23	Do.
do	300	do	1, Tough	14.1	60.4	.4	.9	86	23	Do.
do	300	do	1	13.9	61.0	.1	1.3	87	25	Do.
do	300	do	1	13.4	61.3	.7	1.8	93	22	Do.
do	300	do	1	13.3	60.0	.2	.9	87	24	Do.
do	300	do	1	13.3	60.5	.2	2.0	81	22	Do.
do	300	do	1	13.5	60.5	.3	1.6	72	22	Do.
do	300	do	1	13.2	60.6	.3	1.4	71	19	Do.
do	300	do	2, Tough	14.1	59.2	.9	.8	95	21	Do.
do	300	do	1	13.8	61.1	.2	.9	92	19	Do.
do	300	do	1	13.8	60.8	.3	.9	91	19	Do.
do	300	do	1, Tough	14.3	60.7	.2	.9	92	19	Do.
do	300	do	do	14.7	61.1	.3	.2	90	25	Do.
do	300	do	do	14.1	60.8	.2	.8	93	21	Do.
do	300	do	do	14.5	60.5	1.5	1.3	85	26	Do.
do	300	do	do	14.4	60.6	.3	2.0	91	24	Do.
do	300	do	1	13.9	60.8	.1	.7	92	21	Do.
do	300	do	1 [6]	[6] 13.6	[6] 60.9	----	[6] .9	94	19	Do.[6]
do	300	do	1	13.4	61.0	.3	2.0	96	24	Do.
do	300	Remainder	1	13.9	60.0	.5	2.0	80	27	Do.
do	300	Average	1, Tough	15.0	60.5	.1	2.0	92	24	Do.
do	300	do	2, Tough	14.7	59.3	.1	4.0	86	27	Do.
do	300	do	1, Tough	14.2	60.0	.1	1.6	67	26	Do.
do	300	do	2, Tough	14.2	59.4	.2	3.5	92	25	Do.
do	300	do	Sample, Tough	15.2	58.0	.1	6.0	47	34	Musty.
do	300	do	1, Tough	14.1	60.3	.3	1.4	77	27	Natural.
do	300	do	2	13.7	60.5	.6	3.5	84	26	Do.
do	300	do	2	13.8	60.3	.6	2.6	85	27	Do.
do	300	do	2	13.9	60.0	1.0	3.5	85	25	Do.
do	300	do	1	14.0	60.4	.2	1.8	94	24	Do.
do	300	do	1, Tough	14.2	60.8	.3	1.5	97	24	Do.
do	300	do	do	14.3	60.0	.7	1.5	92	24	Do.
do	300	do	2, Tough	14.2	59.7	.4	2.0	88	24	Do.
do	300	do	3, Tough	14.6	57.5	.4	5.5	77	25	Do.
do	300	do	do	14.4	59.5	.3	5.0	91	25	Do.
do	300	do	1, Tough	14.8	60.8	.2	.8	87	24	Do.
do	300	do	do	14.8	60.1	.4	.8	92	26	Do.
do	300	do	2, Tough	14.7	60.1	.2	2.4	87	26	Do.
do	300	do	2	13.9	59.5	.2	2.0	91	25	Do.
do	300	do	2, Tough	14.2	59.5	.4	2.4	91	24	Do.
do	300	do	Sample, Tough	14.8	58.9	.1	8.0	51	31	Musty.
do	300	do	2	14.0	58.3	.2	3.0	89	24	Natural
do	300	do	2	14.0	60.5	.2	3.0	91	24	Do.

TABLE 45.—*Wheat grade data and bin descriptions for all bins sampled in survey 1936, 1937, and 1938 crops*

WHEAT FROM 1938 CROP

Bin No.	County	Location of bin	Roof type	Bin surfaces contacting wheat: Floor: Material	Bin surfaces contacting wheat: Walls: Material	Bin surfaces contacting wheat: Walls: Number exposed to sun	Bulk measurements: Quantity	Bulk measurements: Average depth	Bulk measurements: Half minimum width
							Bu.	*Ft.*	*Ft.*
S-124	Tippecanoe	Stock barn	Ceiling	Wood on concrete.	do	None	500	4.6	3.2
S-125	do	Granary	Wood shingle	Concrete	do	None	150	3.5	3.1
S-126	do	do	Ceiling	do	do	None	450	7.3	4.0
S-127	do	do	Wood shingle	do	do	None	600	4.5	4.0
S-128	do	Stock barn	Ceiling	Wood	do	None	500	3.2	3.4
S-129	do	do	do	do	do	1	333	6.6	2.7
S-130	do	do	do	Concrete	do	None	1,200	3.3	7.5
S-131	do	Granary	Metal	Wood on concrete.	do	2	360	7.3	3.0
S-132	do	Stock barn	Ceiling	Wood	do	1	500	6.8	3.4
S-133	do	Granary	Metal	do	do	1	109	6.3	2.0
S-134	Clinton	Stock barn	Ceiling	do	do	None	260	4.7	2.0
S-135	Carroll	Granary	Wood shingle	do	do	1	400	8.7	3.7
S-136	do	do	do	do	do	1	400	8.7	3.7
S-137	do	do	do	do	do	1	500	5.7	4.0
S-138	do	do	do	do	do	1	500	5.7	4.0
S-139	do	Stock barn	Ceiling	do	do	None	600	2.5	2.8
S-140	do	do	do	do	do	None	600	2.5	2.8
S-141	do	Granary	Wood shingle	do	do	2	350	7.7	2.1
S-142	do	do	do	do	do	2	350	7.7	2.1

WHEAT FROM 1938 CROP

S-108	Clinton	Granary	Wood shingle	Wood	Wood	2	195	5.1	3.7
S-109	do	do	do	do	do	2	244	4.8	2.0
S-112	do	do	Metal	do	do	2	900	3.3	8.9
S-113	do	do	do	do	do	2	144	3.6	2.7
S-114	do	Stock barn	Ceiling	do	do	None	168	4.4	2.3
S-115	do	do	do	do	do	None	291	4.6	2.8
S-117	Calhoun	do	do	do	do	1	223	3.0	2.5
S-118	do	do	Wood shingle	do	do	2	253	3.0	2.6
S-119	do	Tool shed	do	do	do	None	132	3.0	2.4
S-120	do	Granary	Ceiling	do	do	None	150	4.5	2.8
S-121	do	Stock barn	do	do	do	None	65	3.6	1.9
S-122	do	do	do	do	do	None	34	1.9	1.9
S-123	do	do	do	do	Metal-lined wood.	None	518	4.0	5.7

[1] All wheat of class Soft Red Winter and subclass Red Winter except where noted.
[2] Mixed Wheat.
[3] White wheat of subclass Soft White.
[4] Slight odor of manure.
[5] Commercially objectionable foreign odor probably due to insecticide.

of 1939 of wheat stored under loan in Ohio, Michigan, and Indiana. Wheat of included—Continued

STORED IN INDIANA [7]

Harvest method or source of wheat	Storage period when sampled	Portion of bulk sampled	Official grade of sample [1]	Moisture content	Test weight per bushel	Dockage	Total damaged kernels	Normal germination	Fat acidity	Odor
	Days			*Pct.*	*Lb.*	*Pct.*	*Pct.*	*Pct.*	*Units*	
	300	Remainder	[8] 3	13.5	56.0	0	7.0	74	29	Natural.
	300	do	[8] 3	14.5	56.4	0	2.6	88	26	Do.
	300	Average	2	13.7	59.8	0	4.0	91	23	Do.
	300	do	2	13.2	59.5	0	3.0	90	19	Do.
	300	Remainder	[8] 2	14.2	58.9	0	2.5	84	22	Do.
	300	Average	[8] 2	13.1	58.0	1.8	2.7	86	24	Do.
	300	Remainder	2	13.1	59.4	0	3.5	94	18	Do.
	300	Average	3, Smutty	13.5	57.3	6.8	3.0	87	25	Smutty.
	300	do	3	12.8	59.4	0	3.5	87	21	Natural.
	300	Remainder	2	13.2	58.8	0	1.5	88	19	Do.
	300	Average	2	13.3	59.4	0	3.0	91	24	Do.
	300	Top half	3	12.3	56.7	0	3.5	88	21	Do.
	300	Bottom half	3	12.2	56.7	0	3.0	92	22	Do.
	300	Top half	3	13.4	56.9	0	3.0	89	26	Do.
	300	Bottom half	3	13.7	56.9	0	3.3	92	26	Do.
	300	Top half	2	12.8	59.7	0	1.0	90	20	Do.
	300	Bottom half	2	12.7	59.7	0	1.2	87	20	Do.
	300	Top half	2	12.4	58.6	0	3.0	96	23	Do.
	300	Bottom half	2	12.8	58.6	0	3.2	93	24	Do.

STORED IN MICHIGAN

Threshed	300	Average	[3] 3	13.0	56.0	0.4	2.7	78	25	Natural.
do	300	do	[2] 4	13.1	55.2	.6	4.0	80	27	Do.
Combine	300	do	4, Tough [3]	14.6	55.5	.2	2.0	78	21	Do.
do	300	do	[3] 4	13.8	55.6	.3	3.5	88	23	Do.
Threshed	300	do	[2] 3	13.1	57.2	.2	.7	83	20	Do.
do	300	do	[2] 3	13.0	56.6	.4	.0	92	23	Do.
do	300	do	3, Tough [2]	14.7	57.6	1.7	.9	92	19	Do.
do	300	do	3, Tough [2]	14.1	58.0	1.4	.0	94	19	Do.
do	300	Remainder	3, Light smutty, Tough	15.1	59.6	.8	1.0	85	20	Do.
do	300	do	1, Tough	14.8	61.8	.2	.9	92	17	Do.
do	300	Average	1	13.8	62.0	.1	.5	92	21	Do.
do	300	do	1	13.8	60.0	.3	.4	78	19	Do.
do	300	Remainder	3, Smutty, Tough	14.6	56.3	.7	1.4	80	21	Do.

[6] From sample drawn when loan was made. Survey sample for grade was lost in transit.
[7] Numerical grade and test weight data for all Indiana bins, except S-129, from sample taken about the time bin was filled.
[8] Hard Red Winter wheat of subclass Yellow Hard Winter.

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